

Locating and Gaining Access to Medical and Scientific Literature



Long Range Plan

National Library of Medicine

Locating and Gaining Access to Medical and Scientific Literature

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Medical and Scientific Literature

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Acknowledgments

This report is the culmination of one year of work on the part of the Panel Two members, consultants, and staff. The Panel wishes to thank all those involved for their generous contribution of time and talent to this effort. In particular, the Panel wishes to thank Carol Jenkins, special consultant to the panel, for sharing her considerable expertise and writing skills in developing the Panel report.

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Background and Context

The timely transfer of scientific and biomedical information is the fundamental purpose of the NLM (National Library of Medicine). The Nation's investment in medical research, education, health care, and development can be fully realized only when the results of research are applied by health professionals. For this to occur, the biomedical literature that reports the results of medical research and development must be acquired, organized, and made available to researchers, practitioners, educators, administrators, and students in the health professions.

Panel Two, whose topic was "locating and gaining access to medical and scientific literature," had as its general focus two questions: (1) who are and who should be the users of NLM, and (2) what is the infrastructure necessary to facilitate access to information. Those questions were posed against a background of rapid and massive changes in the amount of biomedical information being generated and in the means available for its transfer and distribution.

The AAMC (Association of American Medical Colleges) report, *Academic Information in the Academic Health Sciences Center: Roles for the Library in Information Management*, succinctly summarizes the state of the art of information access and dissemination:

The generation of new knowledge has continued its unrelenting course, doubling at least every 10 years. The world's knowledge base is shifting inexorably from a paper to an electronic base. New



ways of synthesizing, compacting, and representing knowledge are developing... Transfer of quantities of data and information can be accomplished relatively inexpensively and nearly instantaneously with the use of phone lines, satellites, and microwaves over any distance. The societal view of the importance of individualized access to and control of information is changing; in a highly competitive technologically based world, individuals and organizations with better quality information services are more productive and effective.¹



Rapid technological developments continue to expand the possibilities for information access and dissemination. While technology development in and of itself is important, it must be wed to key integrating concepts, most notably those emerging from NLM's IAIMS (Integrated Academic Information Management Systems),² so that information can be successfully updated, verified, and easily accessed.

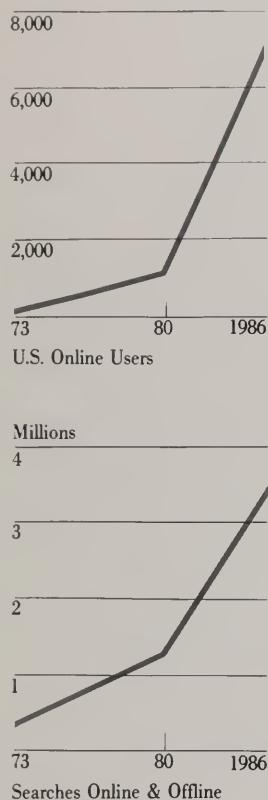
In the following report on access to medical information, Panel Two urges the NLM leadership to recognize and use the strengths

of the existing infrastructure to achieve the scenarios envisaged and described by this Panel. The strongest components of the NLM infrastructure should be closely studied to determine how they can provide base support for our vision of the future. This should include: (1) an examination and possible redefinition of the RML (Regional Medical Library) Network; (2) improvement of direct services to the user of information sources and services; and (3) support for programs of graduate education in library and information sciences. In addition, the Panel strongly supports NLM's efforts to develop technologies related to knowledge-based systems and recommends further improvement in disseminating biomedical information. Panel Two encourages NLM to explore the further expansion of its services to include consumer health information, improved organization and availability of research data, and appendiceal files. Two recent NLM initiatives are strongly supported by this Panel as well: first, the development of a Unified Medical Language is critical to several key NLM directions and would serve also to significantly improve the infrastructure. Second, the IAIMS projects have created effective models that provide a process, framework, and clear set of goals for the year 2006.

Several appendices to this report amplify the text. A 20-year review of the MLA (Medical Library Assistance) Act, prepared by several members of Panel One, provides insight into the information needs of health professionals and how the medical library network can satisfy these needs. A brief description of the NLM planning process is also appended.

NLM Programs and Recent Accomplishments

MEDLARS Online Network



Since 1836, NLM has given health professionals vital access to biomedical information. Starting as a small collection of books by the Surgeon General of the Army, NLM, then called the Armed Forces Medical Library, is today the largest medical library in the world. The Act establishing NLM as a national library under the Public Health Service in 1956 (PL-84-941) formally affirmed NLM's purpose: "to assist the advancement of medical and related sciences, and to aid the dissemination and exchange of scientific and other information important to the progress of medicine and to the public health."

The NLM Act specifies that the Library shall disseminate bibliographic information describing the materials in the NLM collection and shall make these materials available through loans or copying procedures. Together these activities provide access to both the physical collection and information about content (e.g. journal citations and abstracts) that may identify relevant portions of the collection for a particular user.

NLM enhances access to the literature by distributing in a variety of formats indexed citations to articles in journals and cataloging records for books, serials, and audiovisual programs. MEDLARS, NLM's automated Medical Literature Analysis and Retrieval System, was first developed in 1964 to provide automated support to the production of *Index Medicus* and to improve its currency.^{3 4 5} NLM also publishes printed catalogs, the NLM Current Catalog and the NLM Audiovisuals Catalog; lists of biomedical serial titles; and many indexes to articles on special subjects in biomedical journals.

NLM cooperates with other organizations and publications such as the American Hospital Association, the American Journal of Nursing, and the American Dental Association to produce *Hospital Literature Index*, the *International Nursing Index*, and the *Index to Dental Literature* as well as smaller recurring bibliographies and published literature searches. The Library has recently issued an experimental video disk with an accompanying catalog that includes images of 1,000 pictures from the Library's prints and photographs collection.

Using the NLM computer system, over 3,800 institutions and close to 1,000 individual health professionals each year conduct over 3,000,000 searches of the Library's databases. NLM has developed a microcomputer search interface to MEDLINE (MEDLARS Online) that does not require users to have special training in search commands or in MeSH (Medical Subject Headings), the controlled vocabulary used to provide subject access to NLM's indexed citations and cataloging records.⁶ At the same time, NLM is exploring ways to modify the automated indexes to MEDLINE and enhance the synonym structure in MeSH to help health professionals search the data bases more effectively.

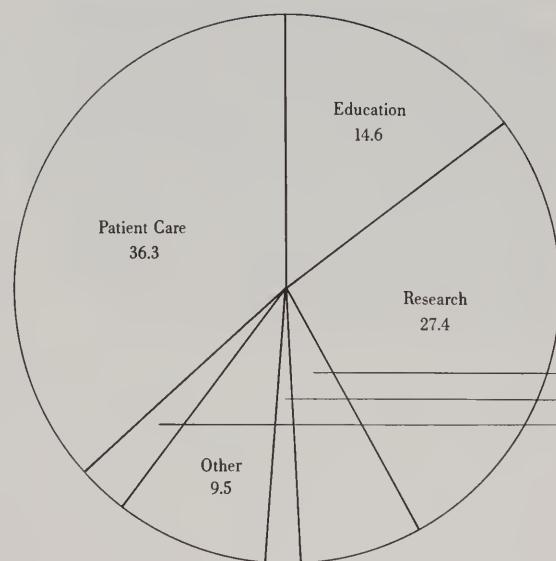
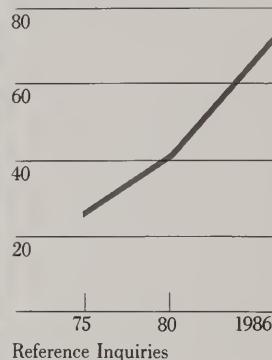
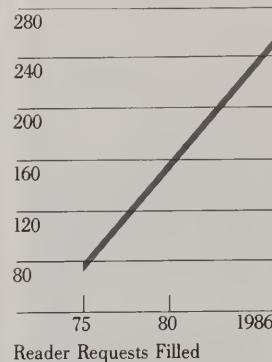
In order to expand the capability of U.S. medical libraries to provide service to health professionals regardless of their geographic location, NLM established the RML Network in the late 1960's. NLM currently contracts with seven major medical libraries in different areas of the United States to develop and coordinate programs for their regions that give health professionals easier access to biomedical information.⁷

One of the important services of the RML Network is document location and delivery. If locally available collections cannot meet a reader's needs, the Network is organized to quickly refer and fill requests for documents from regional resource libraries. Over 2 million requests for documents are filled annually by health sciences libraries throughout the United States. NLM serves as the ultimate backup resource for the network, filling over 100,000 interlibrary requests a year for documents that no other collection holds, mostly photocopies of journal articles. Network participants, including NLM, adhere to standards for turnaround time for processing requests. National maximum charges assure that reasonably priced service is available to health professionals whatever their geographic location.

The development of MEDLARS III, the next generation of NLM's automated system, will provide significant improvements in NLM's online services by providing single-search access to all categories of records via a sophisticated user-friendly query language and greater variety and flexibility in output formats. Both DOCLINE (an automated document request and referral system)⁸ and NLM's online public catalog will display data about the location of specific volumes and issues in the NLM collection. On-site requests for books or periodicals will be routed automatically to the appropriate stack locations within NLM. Improved statistical capabilities will permit more detailed analyses concerning the usage of the medical literature.



NLM Public Services FY 1975-1986 (In Thousands)



MEDLARS Usage Purpose of Search

Percentage of search purpose for each profession

A Vision of the Future



The following scenarios represent the Panel's views on what biomedical research, health professional education, health-care delivery and administration, and libraries will be like by the year 2006:

Research

Biomedical research will be limited to some degree by the same economic constraints that will be shared by all sectors of society, but new discoveries in basic science and clinical medicine will continue nevertheless. The pace and volume of research will be even greater, in part spurred by routine use of data bases and frequent communication among scientists via electronic systems. The trend toward a smaller percentage of M.D.s entering research careers will continue, but close links between clinical settings and the research community must and will be maintained.

Through advanced technology, more tests and procedures will be possible, but economic constraints will permit only some of the fruits of research to be applied. The necessity for increasingly sophisticated and cost-effective choice making will require the use of equally sophisticated diagnostic and decision-making models. Investigators in the health sciences will require greater access to more information than ever before. Data from multiple disciplines will be more accessible because of the development of computerized links among various scientific vocabularies. Thus, the investigations in agriculture,

physics, chemistry, psychology, and veterinary medicine will be of potential interest and possible utility in, and more accessible to, human health-care research. The key challenges will be how to (1) index such data, (2) provide for its rapid acquisition in a format tailored to the user, and (3) provide quality filtering of data. Some clinical studies will involve researchers in geographically separated sites. They will share their results as those results develop, and electronic communication will speed the exchange of clinical questions and answers.

Education

Based on current research about learning styles, new methods will be available to give learners rapid access to the massive volume of known "facts" and data. Conclusions gathered from research on differences in cognitive learning styles will allow users to access data in a format most appropriate to their learning ability—visual, auditory, and so forth. Instruction will be offered in multiple formats. The educator's role will be to teach students how to apply such facts and data to identify and solve clinical problems. The effective clinician, or other health-care worker, will understand and use such problem solving principles. They will not attempt to rely on human memory for information, but will use electronically stored data bases. The purpose of students' meetings with teachers will not be to dispense and absorb information, but to achieve higher-level cognitive objectives and to meet goals in the

affective and psychomotor domains. Facts and memory will be less important. Values clarification, appropriate affective behavior, the ability to understand complex conceptual relations, and the development of clinical judgment and clinical skills through experience will be the focus of faculty-student interactions.

As knowledge expands exponentially, and technologies change with increasing rapidity, lifelong learning must be a commitment of every health professional. Clinical skills will be regularly updated. Humanistic qualities and ethical principles must be steadily reinforced. Education will be a continuous process and a task never completed. Students at every level will be able to tailor the education "package" to their own needs, to access this material at a time and place of their own choosing, and to review, at will, any segment to improve comprehension and understanding. All types of media support will be used, including animation and extensive interaction, so as to portray and then reinforce concepts effectively.

Professional meetings will continue to be important arenas in which the most up-to-date knowledge in a field is shared, critiqued, and disseminated to practitioners, but the form will be different. Health-care professionals will continue to meet, but increasingly by electronic means; the need to travel to educational events will decrease.

While the number of persons prepared in the traditional fields of health-care delivery (such as physicians and nurses) will continue to decline as admissions are further restricted, the actual number of people prepared in a much broader range of health fields (many as yet unknown to us) will be much larger. Strict standards of knowledge and competence will be continued for the traditional fields and established in the emerging fields as well.

Since those health professionals who work in clinical settings will function more as part of a health-care team than is the case now, management and leadership skills that foster interdisciplinary efforts will be important. Teaching will occur in acute, ambulatory, and community settings; teachers will have received special instruction in the teaching/learning process, and they will be selected and evaluated in terms of their teaching abilities. The professional status of teaching will have been elevated.



Medical Practice

Medical practice will have a three-pronged configuration: acute in-patient care; ambulatory/community care; and health promotion and illness prevention. A relatively small population of patients—those who are severely or acutely ill—will receive the special care of a hospital. Hospitals will be smaller as the current trend continues toward concentrating expensive equipment and highly trained staff. Each will focus its interests on relatively few areas, but collectively, hospitals will offer a broad spectrum of illness care. Thus, a patient will be sent to the hospital that has a special focus on his or her condition. The hospital personnel will be fulltime, expert in the requisite technology, and trained as specialists according to their particular tasks. As knowledge and technology advance, a strong program of continuing education will be essential for personnel. They will receive their continuing education through a number of different educational formats based on their cognitive learning styles. Much clinical investigation will continue in such settings, but few students will receive their basic clinical education there.

The bulk of practitioners will work in ambulatory and community settings that will serve the health-care needs of the larger population of patients. There will be electronic linkage and transmission of all data about the patient. In both the acute care and ambulatory/community settings, as patients present clinical problems not readily solved, the health-care team members will be able to access data to address such problems, and to do so during the patient visit. When needed, consultative services will be available to the practitioner on a person-to-person basis, whether on-site or distant. Because varying levels and types of care are offered in a variety of settings, the ability to provide timely and accurate information about the patient's health to experts anywhere will insure good health care.

Health promotion and illness prevention will become increasingly important, and education of the public will assume a larger role in the activities of health-care professionals. The public will have more health-care choices to make, and will therefore need more health information.

Many health-care providers will be specialists or subspecialists, and most of their professional time will be spent in delivery of these skills and services. There will be intense competition among health-care providers due to both personnel surpluses (at least for the next 10 to 15 years) and the reallocation of health-care activities among the various professional groups. While both of these trends may seem threatening to the health professionals of today, the outcomes may well be positive for the patient. Every health-care professional's actions and decisions will be recorded and compared to established standards of practice. Deviation from standards of practice will result in a continuing education program specifically targeted to the health practitioner's deficiencies. Because of the oversupply of physicians, those persons requiring additional education will be glad to engage in the educational effort, as they will realize its advantage for their own careers.

Administration

A more sophisticated management system will control the operation of health care—its facilities, personnel, education, accreditation, and certification. Delineation of privileges will continue to be critical and difficult to manage. The health-care system will be increasingly diverse—both in terms of geography and nature of services. Therefore, “mega-administration” structures and processes will be necessary to ensure the fiscal survival and functional integrity of the system elements.

Library and Information Science

In 2006, the “library” will be very different from the present day library as a physical entity, and will provide a home base for many services, products, and functions that may or may not be located in a central physical location. Despite the highly technical nature of information transfer, there will also be a need for a “high touch” setting for information access. The physical space of the future library will contain a variety of multimedia formats, from printed materials to video disks, from three-dimensional models to computer terminals, and from holography to leisure reading. The resources will be linked by a coordinated system of human and electronic networks. The library will be both the hub of some networks and the gateway to others.

The people who compose this information/communication/library system will be so-called “knowledge professionals,” either specialists in a particular field (medicine, pharmacy, nursing, etc.) or process specialists (educators, instructional designers, librarians,

information and communications people, etc.). These knowledge professionals will provide “hard copy” material (on location) or the “soft” material (that which is located elsewhere) to users, assist with research, and offer technical consultation on and educate for lifelong learning skills. The knowledge professional may also help reformat and interpret the information for the user. The content or process specialists will offer value-added services within their institutions and beyond. Health professionals will be well aware of the important role that information plays in all aspects of the health-care system.

Books, journals, films, video disks, slides, models, data bases, archives, and expert systems will continue to form the hub of information available in the library information system. There will always remain a physical collection that records the current status of medical research and its historical roots.

Major Issues and Future Directions

The scenarios created for the year 2006 suggest a number of opportunities for NLM. These opportunities fall within two major objectives—maintaining and improving the infrastructure for information transfer and providing support for users of health information. This report provides a descriptive model for each major objective. These models represent a conceptualization of resource cost/benefit and market analysis, which can serve as a structure for decisions. Thus, NLM's strategic position enables it to have direct influence on the infrastructure, standards, access, user population, and so forth. However, with a finite amount of resources, the models should help support resource allocation decisions for NLM. Additionally, this report presents some issues and recommendations about access to health information internationally.

Maintaining and Improving Access Through the Infrastructure of Organizational Units

For the purpose of this report, infrastructure means all the components of a system by which information flows from source to user. Infrastructure for our purposes could include technology, people, the current RML Network, telecommunications systems, etc.

The proposed infrastructure model for information access has a number of distinctive features. Principally, it will be a network linking services and sources through a number of “hubs” or “gateways” at various points, which allow access to ever-widening sources of information. The network will function at local, regional, national, or international levels, and ad hoc linkages could be established for specific purposes and discarded or changed as needed. The infrastructure will have an established set of standards that will enable the user to tap into various points within the system. It will also require a variety of monitoring devices that control access, i.e. fee for service, membership, or policies.

In 2006, access to biomedical information should meet these requirements:

- Information should be acquired, organized and made available so that the user can select the most appropriate information needed in the most convenient form and location.
- Information access should appear as a one-step process from the user's perspective.
- Information should be supplied directly to the user.
- Access should not require complicated technical training; however, conceptual training in the principles of information management will be required.

- Access should be cost-effective for the user.
- Information should be accessible to all who need it regardless of their ability to pay.
- Access to information should be accomplished via pathways employing the most up-to-date and effective computer and telecommunications technology available.

NLM is in a strategic position to provide infrastructure components for the medical information network in the United States and possibly the world. Several of the significant areas in which NLM can contribute are quality, standards, and access—both physical and intellectual. NLM is also in an excellent position to establish national standards and influence international standards for information organization, storage, and distribution. For example, in the access area, the current RML Network provides one potential path for physical access and information services throughout the country. Private and not-for-profit systems will provide other paths for access to information. The intellectual access is provided by the indexing and abstracting tools as well as the various data bases and reference services, which in turn allow access to the information and/or the physical collections.



Linkages and Networks

Regional Medical Library (RML) Program

The support system for disseminating biomedical information will consist of a variety of multilayered networks. Twenty years ago, the mechanisms for obtaining access to bibliographic and textual information and data were limited. Thus, the hierarchical RML Network developed by NLM starting in the late 1960's established repositories of resources, created bibliographic access systems for learning about those resources, and defined protocols and policies for obtaining resources as needed. The mission of the RML Program is to provide health science practitioners, investigators, educators, and administrators in the United States with timely, convenient access to health-care and biomedical information resources.

In 1986, the RML Program is one of the main components of the NLM infrastructure. Completed in 1970, the Network has been a major instrument through which NLM has carried out its mission. Through a national ILL (Interlibrary Loan) system managed by the RML Network, NLM provides health professionals with access to the actual documents of medical literature. The RMLs have brought

the technologies of computerized searching to basic health science libraries and given health professionals access to medical literature. NLM currently has contracts with seven major medical libraries throughout the United States to develop and coordinate regional programs that improve access to biomedical information by health professionals.

Panel Two recognizes that the pattern of referrals to larger collections may not be the most effective model for locating and obtaining biomedical information in the next 20 years. An updated regional network is needed that supports individual access to information through a variety of sources at multiple levels. For example, at one level, an individual can maintain personal data bases including raw data, synthesized data, bibliographic and textual data, and anything else deemed useful by that individual. At another level, the same individual would have access to external data bases that could contain bibliographic or full-text information, synthesized information in knowledge data bases, expert systems to support decision-making processes, and many other data bases of varying degrees of complexity.

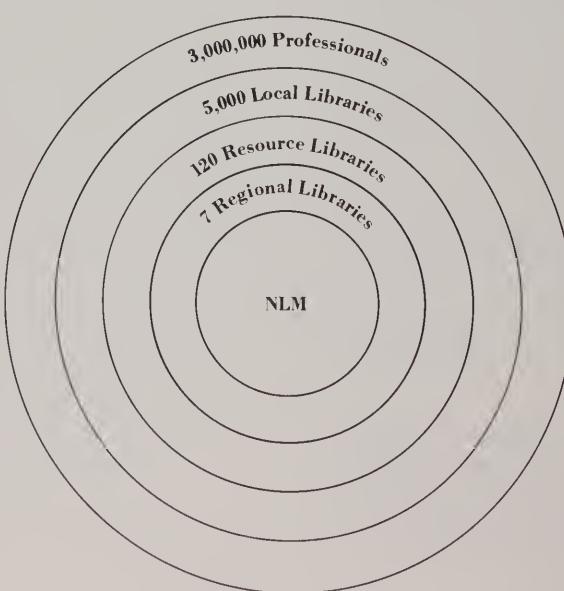
While the current DOCLINE system for ILL provides health professionals with access to

NLM

Acquire 25,000 Journals
Reader and Reference Services
Index and Catalog, Publish
Document Delivery
Build ONLINE Data Bases
Central Computer Facility
Grants to Libraries
Audiovisual Programs
Research and Development
Training

Resource Libraries

Acquire, 2,000-3,000 Journals
Reader and Reference Services
Document Delivery
ONLINE Services
Engage in Consortia



RMLs

Acquire, 3,000-5,000 Journals
Reader and Reference Services
Document Delivery
ONLINE Coordination
Training
Encourage Consortia

Local Libraries

Acquire, 100-200 Journals
Reader and Reference Services
Document Delivery
ONLINE Services
Engage in Consortia

biomedical literature, further links should be developed to provide relevant documents in any field required. These documents may be in subject areas related to biomedicine, e.g. biology, chemistry, sociology, or in support areas such as economics, facilities management, or statistics. Currently, this literature may only be available through other networks not easily accessed by the health professional.

Integrated Academic Information Management Systems (IAIMS)

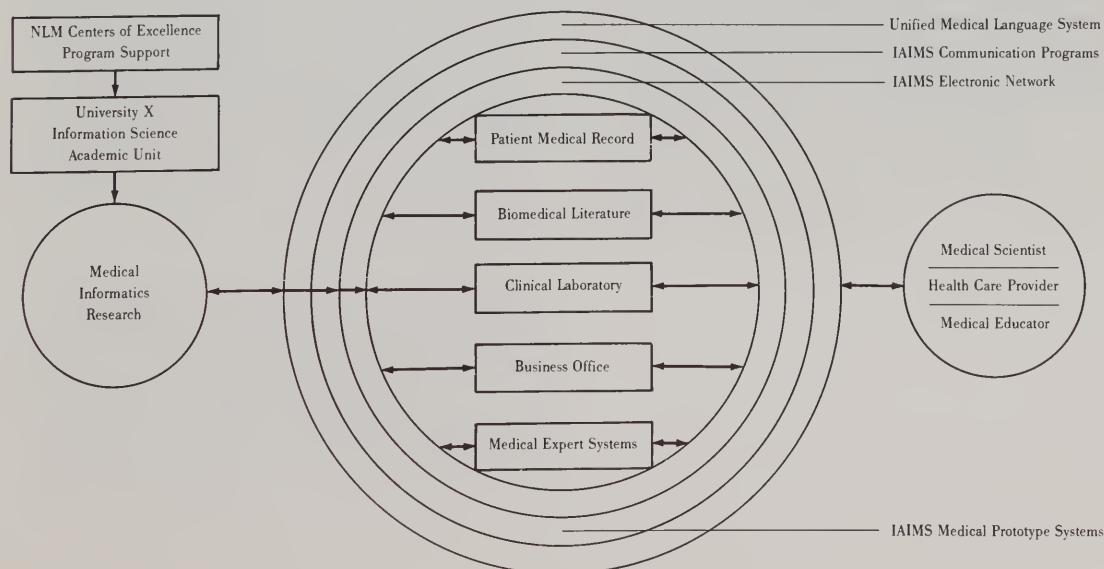
In 1983, NLM began funding planning sites for the development of IAIMS prototypes. IAIMS refers to the basic principles of linking academic information (library-based information, information from specific data bases, and so forth) to specific purpose information (i.e. clinical information on specific patients). Each experimental site was required to develop a planning process for implementing this idea into the academic health center. After the planning process, centers were encouraged to apply for a model test grant in order to evaluate the results of the planning process.

Although during the next two decades, information resources will increasingly be available in electronic form, much valuable information will still exist only in print. Thus, the

physical repositories will be a vital part of the access model. Although libraries will be the primary site for these ever-growing repositories, libraries will continue to expand their service roles as well. Despite the increased availability of computer-based support for individual health professionals, not all such individuals will feel equally comfortable using these systems. These individuals, others who lack computer access, and still others who seek assistance in developing more sophisticated information-handling skills, will depend on libraries in the biomedical communications network to offer relevant support services.

Reference Referral

In addition to offering these two established programs, NLM is in a unique position to provide national reference referral services. Building on knowledge bases consisting of local, regional, national, and international resources that exist in a range of formats from traditional paper to electronic form, and combining this with expertise in information transfer and dissemination, NLM could provide linkages to bring requesting individuals and institutions together with an appropriate source of response in an effective, timely, and cost-efficient manner.



Integrated Academic Information Management System

Summary

An updated model for information access should reflect the variety of information suppliers. These will include individuals, academic and other institutions, commercial and nonprofit organizations, vendors, libraries of all types represented both as distinct organizations and as members of various types of networks and utilities (some including other types of libraries), and perhaps other suppliers, yet to be identified. The model should be flexible, allowing an individual to directly perform his or her own information search or relegate it to an intermediary.

The updated model will identify pathways using the most current computer and telecommunications technology available to link an information requestor with the information source. The model will also employ other electronic networks as necessary to speed the information transfer process.

NLM should ensure that an infrastructure is built that accommodates these several levels of information delivery and their related technologies. The continuing transition from the simple hierarchical infrastructure to a multidirectional one will be gradual. The IAIMS effort, the RML Network, and reference referral are logical mechanisms for assuring that the transition occurs as easily as possible, and also for assuring that health professionals are brought into the infrastructure as both seekers and providers of information.

Standards

The networking infrastructure envisioned can be successful only if appropriate standards are established and broadly accepted in the biomedical information world. Only then can internodal transfer of data and knowledge be efficient, reliable, speedy, and effortless.

Such standards must apply to health information products, systems and services, health facilities, and personnel. NLM will be in a position to set standards in some areas, and to support the efforts of national and international organizations in others. Standards serve the purposes of establishing qualitative or quantitative measures of value, as well as providing desirable uniformity and comparability in performance.

Bibliographic Standards

Health investigators, educators, and practitioners will have an increasing concern for the quality of the information they use, as more information from a wider variety of traditional and nontraditional sources becomes available. The issue of how to establish valid quality filters at an intermediary level is likely to be addressed at many levels, including library/information specialists, professional health and information services organizations, journal publishers, and other data base creators. At NLM, some quality filtering occurs now through the process of selecting publications for indexing. This process creates a de facto standard. Since NLM's standards serve as a model for data base creators worldwide, NLM should strive to maintain the standards it has created for bibliographic information.

Apart from the quality control issue, the transferability of data base contents depends upon the adoption of standard nomenclature that will link terms commonly used by various health-related disciplines and sectors. NLM should assume a leadership role in the

development and application of a Unified Medical Language System. The Unified Medical Language System is one way to develop standards for data base content and format, whether the data bases be bibliographic, factual, interpretive, raw research data, or patient records.

Over the past two decades, NLM has supported appropriate standards of quality for medical libraries, ranging from small hospital libraries to major academic medical center facilities, collections, and services. Most recently, NLM has supported the development of new guidelines for excellence in academic health sciences libraries, and has encouraged such libraries to become leaders in designing IAIMS on their campuses. NLM should continue to support the development and application of standards for libraries as a major point of access in health information systems.

Content and Systems Standards

At the same time, the new means of access call for new standards of education for information management on the part of health professionals and information specialists. NLM should support the development of training programs that will raise the level of "literacy" in medical information systems to a higher standard.

NLM should be aware of the potential for expert systems and clinical decision-assistance systems to enhance high standards of health-care practice. The ability to track a physician's performance, or to determine liability based partially on use of an available information system, may be commonplace by 2006. NLM's role is to assure the development of high-quality information support systems that can help achieve the highest standard of health care for the Nation.

Panel Two believes that at the present time, preservation of and access to the raw data upon which biomedical research conclusions depend is a neglected area of science that should be of concern to the research community. A great deal of data is effectively unavailable to the scientific community beyond the investigator who collects and analyzes the data. No institution has responsibility for maintaining files of primary data and making them available to other scientists. Panel Two believes that in 2006 researchers in the health sciences will require access to bodies of information that they themselves did not or cannot collect and will also need to access data from other disciplines. Investigations in agriculture, physics, chemistry, psychology, and veterinary medicine, as well as the biological sciences are of potential interest and possible utility in human health-care research. As investigators become more interdependent, it will be increasingly important for some centralized agency to assure the availability of primary research data and appendiceal files. By the year 2006, it will be possible to make this data more easily and readily available, leading to an increased activity in secondary analysis. En route to this end, there are many fundamental questions of quality, standardization, and documentation to be addressed. Accordingly, Panel Two recommends that the leadership of NLM consider the issues of preserving and disseminating raw data and bring them to the attention of the concerned community. These issues might include guidelines appropriate for acquiring and storing research data, along with defined routes for users to access these data.

Nomenclature Standards

For decades, a fundamental obstacle to widespread adoption of computer-based medical information systems has been the absence of standard vocabulary, terminology, definition, and criteria for recording the results of biomedical research, the events of clinical patient care, and the managerial and business transactions of hospitals. However, there is the worldwide adoption of the NLM MED-LARS system for access to bibliographic citations of the scientific literature, based on the MeSH thesaurus and indexing system.

The breadth and depth of NLM's MED-LARS experience qualifies NLM for a leadership role among interested American health-care constituencies in designing and executing a computer-based system for linking terms in various health-related vocabularies. This vocabulary system would be the foundation on which can be built the effective integration of information systems in the library, the clinic and hospital, the classroom, and the administrative center.

With adequate additional funding for this program, some system parts would be available for testing within the first five years, and by 2006 the Unified Medical Language System will have been developed and will be in widespread use throughout the health-care field.



Technology

It was the computer that made possible the speedier and more flexible search of biomedicine's ever-expanding data base; and it was the earth-orbiting satellites that enabled the world-wide transmission of the computer's signals. The future will undoubtedly involve NLM in the development of new distribution methods. These may include high-speed satellite links; distribution of bibliographic data bases on compact disk; new cataloging methods such as workstations that semi-automated indexing; pre-indexing by authors or publishers at the time of composition or issuance; and more sophisticated data base tools like full-text document retrieval and expert system data base management.

Computer-Based Technology

One new technology, parallel processing, can simplify information searching and will be of even more use with storage and retrieval of



full-text documents. At the frontier of computer technology is the parallel processing used by special text-searching hardware to identify complex patterns in freely formatted text files. Three commercially available devices currently search free text at rates of 1, 2 and 10 million characters per second for complex patterns up to 10,000 characters in length, while allowing a considerable degree of arbitrary mismatch to the pattern (to accommodate misspellings, foreign spellings, etc.). These devices should be evaluated for use in direct serial searches that are used during cataloging, indexing, and during data base retrieval requests.

The amount of medical information available in full-text machine-readable form will be growing exponentially during the next 20 years. This massive increase in publications that can be processed immediately by computer will present both a great problem and, at the same time, a great opportunity. On the one hand, the total amount of new information can be overwhelming; on the other

hand, one can envision an automated processor that indexes and catalogs journal articles. By establishing standards through relationships with publishers, it should be possible to obtain computer-readable versions of titles, authors, and abstracts in NLM-standardized formats even before obtaining the manuscripts themselves. Incentives for publisher participation could include earlier inclusion of a journal's contents in NLM's data bases.

Indexing and cataloging of computer-readable material could be greatly facilitated through rapid text-searching technology that relies on parallel serial search machines. Such rapid text-searching machines could be coupled with expert systems whose rules could identify familiar concepts and discover novel ones discussed in the paper. As heuristics for recognizing novel concepts in manuscripts are developed, the "technological" cataloging advisor could become a "cataloguing expert." Development of expert-system driven text-analysis systems would take an immense burden off human catalogers and might be the only feasible way to keep up with the growing overload of information. The development of such expert systems should be undertaken in a carefully organized, highly focused manner, attempting to capture the expertise of some of the better human catalogers in a relatively narrow field. Once developed, the methods developed for generalizing the application to other fields will be much simpler. In particular, the development of a Unified Medical Language System would be greatly aided by the use of both the rapid text-searching tools and expert systems.

Computer-Assisted Technology

Many technological devices today are not computers, but receive assistance for operations from a computer. The information infrastructure, for example, has several computer-assisted components, such as up-to-date telecommunications systems that allow connection with multiple data bases and electronics and microwave systems that rely on satellites to transfer and retrieve information.

Summary

In order for NLM to be a leader in applying each of these technologies, Panel Two proposes that NLM evaluate their use in at least one project. The project would be aimed at solving at least one of NLM's own problems. One good example is the effort of NLM to record photographic documents on compact disk. Another example is current collaboration with an author and a publisher to prepare a completely cross-indexed and full-text searchable version of an exemplary reference work on a video disk. Texts heavily dependent on graphic materials in fields such as dermatology or radiology are ideal test material for trials. Such experiments could set de facto standards for access to a wide variety of full-text documents with a minimal investment from NLM.

Supporting Access to the Infrastructure by Users of Health Information

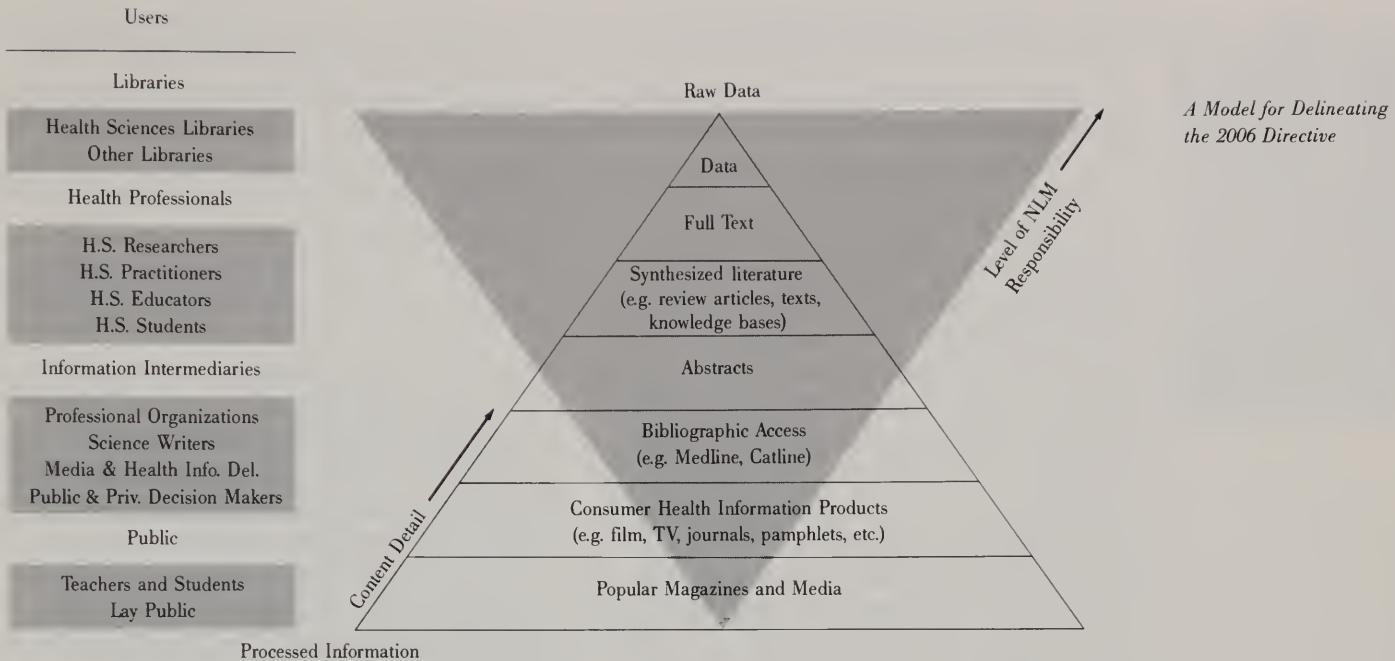
Users: A Model

Using the projection of the health-care and library/information science environments in the year 2006, Panel Two developed a model to depict the primary dimensions and elements that shape NLM's role in providing access to health information.

This model is presented in the figure on the opposite page. It has three primary components: (1) users of health information, (2) health information sources ordered according to the detail of the content, and (3) NLM's level of responsibility as it relates to the delivery of these types of information to identified users.

Users

Potential users of NLM's health information resources fall into four categories: (1) health science and health-related libraries, (2) health science researchers, practitioners, educators, and students, (3) agencies and organizations that interpret and report health information and/or set health-related policy, and (4) the general public, including teachers and students. In general, the detail of health information content required by each of the user categories varies in a relatively predictable fashion. That is, researchers require information at its most detailed level, while users in the "public" category require information that has been condensed from a variety of sources. Timeliness is another significant variable. For example, among researchers and health practitioners, timeliness of information is critical; while timeliness is certainly desirable, it may not be as critical for other user groups.



Health Information Sources

In the model, health information is depicted as a triangle. At the apex lies the most detailed level of content—the raw data that result from research and clinical reports. The remaining information sources are categorized and arranged in descending level of detail and, correspondingly, increased amount of synthesis or interpretation, ending with the popular health-related literature. The information needs of the user groups at the top of that listing will, in general, correspond to the level of content detail that appears at the top of the triangle. However, it should be noted that the divisions between content detail levels are light lines, not heavy ones, which is intended to imply that any user may move up and down through the content detail levels as his/her varying health-information needs dictate.

The choice of an upright triangle to “contain” the levels of health information sources has a number of graphic purposes. The width of the triangle is an indicator of the actual numbers of users—both individual and aggregate—that are likely to make use of the information at each level of complexity. Thus, while relatively few individuals—primarily researchers and practitioners—need raw data and full text, the general public has a growing awareness of and need for health information available in the media and popular press. Second, the width of the triangle also is meant to convey broadly the actual volume of information that is available to users at the varying levels of content detail. Finally, the width of the triangle is an indicator of the number and variety of sources from which the information can be obtained.

Level of NLM Responsibility

The level of responsibility that NLM should assume for activities that support the information needs of users' constituencies (both current and recommended) is the third primary component of the Panel Two users' model. This element is depicted as an inverted triangle superimposed over the health information triangle. Where the triangle is widest (at the top of the figure), it is expected that primary support of the related information-management activities would be provided by NLM, and that the expenditure of resources would reflect the commitment accordingly. Near the lower tip of the inverted level of responsibility triangle it is expected that, while NLM fully recognizes that there are numerous users in need of less complex information, fewer NLM resources would be directed toward meeting those needs. For example, the lower end of the level of responsibility triangle extends into the information level containing sources in the popular press.

Opportunities to Improve Access for Users

Decision-Support Systems

Panel Two's vision of the future includes a variety of decision-support mechanisms, such as expert systems that would improve or ease access to health and biomedical information at NLM.

An area of great importance to NLM is the application of knowledge-based systems to the problems of simplifying access to bibliographic data. Knowledge-based systems support decision making by linking technology and content. For example, the current MEDLARS index of the literature serves as a conceptual framework for the entire body of published medical literature. This framework contains both syntactic and lexical knowledge

that is best represented in a knowledge-based system. Hence, putting MeSH terms into a knowledge base would be a relatively straightforward task. The knowledge-based system would maintain consistency and would perform all the cross checks necessary to maintain a proper hierarchical relationship between all the terms in a search and their attributes.

In addition to advocating the use of expert systems for cataloging and indexing, NLM should consider giving strong support to groups that are using these methods to codify and represent knowledge in the biomedical sciences. Expert systems can represent, in an immediately useful form, very large amounts of information in a highly compact form that will be readily disseminated. Along with the development of knowledge-based expert systems, methods for reviewing and judging the quality of the information they contain will have to evolve. That task should be left to the usual peer review methods, such as editorial boards or ad hoc reviews.

Expert-system technology would also help index and formulate queries of the bibliographic data bases. These two processes, indexing and querying, are complementary, and both require large amounts of expertise and trained personnel for efficient use of the current data base. The complementary nature of these two processes suggests that it would be most profitable to prepare an expert system that could automatically index routine publications and that could serve as an expert adviser for other, less routine publications containing novel concepts. Such expert systems for indexing publications will not be widely used until most publications are available in computer-readable form.

Lifelong Learning

By 2006, it will be essential for all health sciences professionals to have the information-seeking skills necessary for lifelong learning in a technological environment. NLM achieved the online revolution in health sciences libraries with its vision of intellectual access to medical literature for all health sciences professionals and its successful application of online, interactive computer technology to the searching of machine-readable data bases. Recognizing the importance of training for successful implementation of MEDLINE search services, NLM took the leadership in providing training programs for librarians as online searchers.

Current advances in information technology provide health sciences professionals with the capability of meeting their information needs through direct access to a constantly expanding number of online information resources. There are hundreds of online data bases, increasing numbers of publications available online in full text, and advances in automated systems to aid the practitioner in making clinical decisions. Given major advances in information technology, and concomitant rapid changes in the practice of medicine, it is most important that health sciences professionals be prepared for their roles as lifelong learners. To use online information resources effectively, they must become expert in evaluating the limitations of information resources, retrieving information from a variety of online files, and organizing information for use.

NLM shares responsibility with academic health centers and health sciences professional societies for training health sciences professionals and students. This training can give new prominence to the role of the NLM-RML Network in disseminating new technologies for health sciences information access and in providing educational programs on

their applications. Health sciences faculty and librarians must also be trained in educational methodologies and computer applications, in order to take the lead in developing innovative teaching programs.

Health Promotion

The 2006 scenario indicates a more health-conscious consumer population, and thus a system of information to support the consumer needs must be in place. The American public desires information that can be useful in positively influencing each individual's own personal health outcomes and those of the family. The scope of health-related information needed includes information about previously diagnosed clinical conditions, as well as common health problems that can be prevented or controlled, such as diabetes, muscular dystrophy, use of alcohol and tobacco, and nutrition and diet.

Some of this desired information now exists in formats and content intended for lay use. However, the range of subjects that has been addressed is small compared to the anticipated demand. Further, access to this information is often difficult because the sources are largely unknown to the public.

One or more agencies or institutions are needed as advocates for the public to identify and develop authoritative information sources designed for general public access, to encourage expansion of such information to cover particular current public-information interests and needs, and to promote mechanisms for assessing the quality of such offerings.



A variety of health information products that focus on prominent health problems already exists. General sources include health information offerings on radio and television. The quality of those sources varies greatly. All too frequently, the reporter or presenter lacks the appropriate background or adequate resources to present consistent, reliable health information. Other, more authoritative sources that focus specifically on health information include voluntary health organizations, local medical societies, medical institutions, medical schools, hospitals, government agencies, and private entrepreneurs. Examples include videotapes produced jointly by the ACP (American College of Physicians) and the Upjohn Corporation covering common medical problems such as pain, arthritis, and diabetes. Other examples are printed subscription health information sources that explain new advances on common health conditions and problems (Mayo Health Letter, Harvard Health Letter). Some medical societies have offered videotapes explaining specific health conditions through local public libraries as a public service.

At present, there is no one general source for identifying and locating available consumer health information products or services or for documenting the circumstances under which they have been produced. Unfortunately, newly produced information resources may duplicate or be of lower quality than existing material. A data base that identifies authoritative consumer health publications could reduce the cost of reproducing such information locally while enhancing the quality nationally. Such a data base should identify high-quality information appropriate for a variety of users. Some of these users could then provide accurate biomedical information directly to the public.

Panel Two's view of 2006 predicts that health promotion and illness prevention will become increasingly important, and education of the public will assume a large role in the activities of health-care professionals. The public will have more health-care options and participate more fully in their health-care decisions. Thus, for both health professionals and consumers, authoritative sources of information regarding health protection and health maintenance will be a significant body of literature. Assisting health-care deliverers to identify appropriate health information for consumers will be a highly valued service to the health-care industry and to American society in general. Panel Two believes that NLM should undertake a study to outline the scope of this effort.

International Issues

Information Transfer to Developing Countries

There is a vast international need for health information. The range of information needs varies as much internationally as it does among U.S. health information users. Less-developed countries may have different needs for information or require different kinds of information than the developed world. The health information needs of developing countries are enormous. Developing countries throughout the world lack adequate health information libraries, have sorely limited facilities for the training of health service personnel, and must depend on a large number of field workers who may have inadequate education.

NLM is in a key position to enhance the health education and information status of these countries. NLM could provide access to information for the training of health providers, health educators, and health service administrators. Libraries in most developing countries are usually very limited or

nonexistent. Access to NLM or some regional equivalent could help compensate for those libraries. With ever-improving technology, information support for rural health workers could be provided. This would constitute a dramatic improvement over the kind of support currently available to rural health delivery. Links with NLM could provide health personnel throughout the world with consultation support that would otherwise not be accessible.

NLM could help assess information needs and the type of communication channels necessary to deliver the information, design information systems of maximum utility, and train personnel of developing countries to establish information systems. Consideration should be given to identifying possible regional information centers linked to NLM, that would, in turn, support a group of countries. This model could benefit from the successful experience NLM has had with its current national/regional library system.

The following steps are proposed to implement the necessary NLM linkage program with developing countries.

- A series of international meetings to identify the health information needs of developing countries and to identify resources that might be available through NLM.
- The establishment of criteria for creating NLM linkages, including telecommunications infrastructure, host government support requirements, personnel requirements, etc.
- The establishment of training programs in the design and support of health information systems.

- Identification of sources of financial support and technical assistance for the establishment of an electronic network with the Third World. While it is clear that considerable resources will be required, it should be pointed out that a number of communications satellite facilities and ground communication services already exist; usually these are owned by the government. Moreover, international donor agencies and foreign assistance programs often are interested in supporting efforts to improve health services in developing countries. NLM is in an excellent position to contribute substantially to that improvement.

Information Exchange

Although a considerable portion of the research done abroad is published and available to U.S. professionals through electronic data bases and published literature, there is still a great deal that is only available in more local data bases accessible through foreign national systems and networks. Some of these files complement MEDLINE; others provide unique intellectual access to specialized information sources, as well as bibliographic and factual data.

NLM, with its long-established relationships with foreign national centers, is in a position to provide U.S. health-care professionals access to information and data generated outside the United States. Although the need for this information is broad-based, most health professionals would probably not have a need to access such files on a regular basis. NLM should be a source of information on the contents and features of international data bases and could provide a search service for both individuals and search intermediaries. NLM should also serve as a link to foreign expertise.

Observations and Recommendations

Getting from 1986 to the electronic world of the future will be a long evolutionary process. Progress will be achieved by building on the strengths of current programs and services as well as by providing aggressive support for the new initiatives recommended.

Panel Two believes that NLM's role is to assure access to all forms of literature in order to facilitate the transition from the printed literature to electronic literature and to prevent any discontinuity in access to information during this transition. Maintaining continuity of cataloging information is also important so that we have a national resource and not only resources at the local level. This maintenance of the traditional role of NLM emphasizes the importance of its archival activity as the world's memory bank of the scholarly biomedical literature. NLM should protect the budget support for its traditional mission of acquiring, organizing, disseminating, and preserving the world's biomedical literature as visions of the future place greater and greater demands on scarce resources.

NLM should provide health-care professionals and organizations with the services necessary to assure access to needed biomedical information. The Library may provide this access itself using the most up-to-date technologies and/or through other libraries or public and private organizations, as appropriate. The Library has the responsibility to assure that quality of access is the highest reasonably possible. The education and training of librarians/knowledge workers must be supported to produce personnel capable of assuming leadership responsibility for the challenge at hand, promoting information management principles and practices, and supporting lifelong learning.

NLM must continue its visionary support of basic and applied research. Its research programs must lead to the establishment of the

information networks, systems, and services that support and enhance the infrastructure and user services and programs.

It must be recognized that the IAIMS initiative provides opportunities for the redefinition of the roles and responsibilities of libraries. Continued support for IAIMS development and research on that development ensures that the infrastructure will be grounded by sound planning, tested models, and empirical research. Projects such as IAIMS will provide information valuable in projecting the requirements and features of the future infrastructure and its users. The RML Network will provide the continuity necessary during the transitional period to make certain that NLM's programs and services maintain their present quality. During the transitional period, the RMLs will bear primary responsibility for technology and knowledge transfer. They should function to amplify NLM's products, services, and technologies by disseminating them productively to resource and basic libraries. In turn, the Network participants will pass the resources of NLM on to the user. An effort must be made, however, to closely examine the RML model.

NLM should continue to work with the Nation's libraries and other organizations as appropriate to establish overall principles under which information is made accessible. One such principle is the need to underscore the intrinsic worth of information apart from its economic value, which is subject to change. NLM must set de facto standards that will be followed by other information producers so that these groups and their products will be effectively linked into the infrastructure described in this report.

Panel Two recommends some specific steps for NLM to take in moving toward its long-range goals. Those steps emerged from discussions on the Panel's view of the year 2006

and the windows of opportunity it has identified that lead to the 2006 goal. The recommendations section is parallel to the presentation in the report and is divided into two major groupings: those that support the infrastructure and those that support the user access grouping.

Support for the Infrastructure

(1) The RML Program, which is the major building block of NLM's current infrastructure, is an invaluable tool for enhancing both direct and intellectual access in the future. NLM should use the RML Network as a vehicle for urging libraries and individuals into the new networking structure, as well as for maintaining appropriate existing systems of physical and intellectual access. NLM should evaluate the RML Network and develop a strategic plan for its future that will include the extension of the new technologies for information and data base access to health professionals regardless of their geographic location.

(2) The current document delivery network should be linked to existing or new networks to provide comprehensive document delivery service to the individual.

(3) NLM should provide national reference referral services.

(4) NLM should expand its support of IAIMS planning, model development, and research efforts. A research program should be initiated by NLM to rigorously examine the various planning processes and models, frameworks, and outcomes produced by the IAIMS sites (for example, from 1983 to 1987). The goal of this research would be to determine those aspects that can be generalizable to other institutions and those aspects that are functionally unique to the particular sites.

(5) NLM should work cooperatively with data base producers and information services suppliers in the private sector to advance uses of technology that facilitate access to health sciences information. The cooperation with private and other public organizations will build a synergy for outstanding creative developments.

(6) In support of building the infrastructure, NLM should support individualized access (both physical and intellectual) to needed information. NLM should encourage research projects in such areas as access to textual information via electronic means and other technology, such as telefacsimile, disks, etc., health information data base development, automated health information delivery systems, medical library automation, and health information expert systems and consultation networks. Specifically, NLM should explore technologies that will facilitate the full integration of information.

(7) NLM should develop knowledge-based expert systems to aid the novice user in retrieval from MEDLARS.

(8) NLM should assume a leadership role in the development of a Unified Medical Language System. All elements of the health-care system in the United States should be encouraged to contribute to its development to facilitate more accurate and effective communication.

Specifically, NLM should:

- Obtain NIH interinstitutional support for a program initiative to create a Unified Medical Language System.
- Seek additional funding for this research area.

- Coordinate program efforts with the American Medical Association and other health professional associations; university investigators in academic departments, including information science, computer science, and biomedical disciplines; health sciences libraries; insurance and information industries; and other Government agencies.
- Draw upon the resources of the Lister Hill National Center for Biomedical Communications as well as grants and contracts to stimulate a comprehensive research program with internal projects, extramural research at universities, and development work by private industries.

(9) NLM should continue to exercise leadership in setting standards of quality through the programs it develops to accomplish its mission of access. NLM should also work with a broad representation of national and international standards organizations, professional societies, public and private service organizations, and others to develop and maintain national and international standards for health information products, services, facilities, and personnel. It is envisioned that such standards will provide a beneficial protective effect to the public by constituting a value system that encourages participants to strive for excellence. NLM should also recommend an approach to the standards required for the preservation, storage, and access to research data and appendiceal files.

Support for User Access

(10) NLM should undertake a study to consider the public's need for health information. This should be in conjunction with appropriate agencies, and the report should recommend an approach that will assure that appropriate health information is available and accessible to the public. Such an assessment might include, among other considerations, the following:

- The scope and magnitude of current sources of consumer health information.
- The range of subjects covered by authoritative, factual information.
- Feasibility of bibliographic control of these information products and services.
- Appropriate agencies or institutions that would disseminate such information to the general public.
- What role the biomedical communications network might have in disseminating such information about the sources of health information.

(11) NLM should encourage the establishment and maintenance of programs to educate and train health information professionals. The education programs should emphasize the focus of "integrated information" concepts. Attention should also be given to the management of information centers and the application of advances in computer technology to information dissemination.

(12) NLM should provide all reasonable assistance to health-care professionals and organizations in other countries in identifying and gaining access to available health information sources worldwide, and in determining the relative level of sophistication and general quality of such sources. NLM should also provide U.S. health-care professionals access to information and data generated outside the United States.

(13) NLM should assess health professionals' need for information (how they get it, use it, evaluate it, and what impact their access to information has on the quality of care they provide). NLM should also encourage further study of the impact of electronic technology on health professional's "information processing" behavior.

Summary

In conclusion, Panel Two acknowledges the strong leadership role that NLM has played both directly and indirectly in influencing the high quality of information available in the health area. Panel Two encourages NLM to continue on its quest for excellence in the integration of information by continuing its commitment to developing an easily accessible system for all who need information. Panel Two further encourages NLM to continue the best possible services and products today and to research the services and products for the 21st century.

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Appendix A

Medical Library Assistance Act: A Twenty-Year Review

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Introduction

In 1965, the U.S. Congress enacted the MLA Act (Medical Library Assistance Act)—Public Law 89-291—to help health sciences libraries cope with the unprecedented expansion of biomedical knowledge and to insure delivery of this knowledge to health professionals, regardless of their geographic location or proximity to a developed library. The MLA Act was the direct result of the report of the President's Commission on Heart Disease, Cancer, and Stroke, which recommended that the government recognize public information as a primary responsibility and major instrument for preventing and controlling disease. In light of the National Library of Medicine's 1986 planning efforts, it is appropriate to review the original intent of the MLA Act, record the progress made since 1965, and project the future needs of the nation's health sciences libraries.

Part I of this report (I) reviews the information needs of health professionals before the MLA Act was enacted; (2) traces the evolution of those needs from 1965 to 1985; and, (3) projects future information needs. Part II of the report describes both developed and proposed programs that are necessary to meet those information needs now and in the future. Among the programs described are the original seven MLA Act initiatives, MEDLARS (Medical Literature Analysis and Retrieval System), and IAIMS (Integrated Academic Information Management Systems).

Summary of Recommendations

For ready reference, the report's specific recommendations for future action in ten areas are summarized below. The recommendations center around the continued need for a strong and effective BCN (biomedical communications network). The continued growth in scientific information and the increasingly interdisciplinary nature of scientific research require that health professionals have access to information from an overwhelming variety of sources. Thus, a BCN which provides access to this information through one gateway (to be defined as a set of simple computer commands that permits an individual to access all relevant information data bases, each of which usually must be searched by a unique search protocol) is essential to meet the information needs of tomorrow's health professionals.

Health Information Needs

Health professionals should be aware of and trained to use modern health information resources including bibliographic and factual data bases, hospital information systems, and expert systems. These resources should be accessible electronically, easy to use, not restricted to disciplinary lines, and accessible from multiple locations and by a variety of equipment.

Medical information sciences (medical informatics) will be an increasingly important discipline. Training should be provided in health professional schools, and this specialty should be given appropriate academic recognition.

Given the current emphasis on individuals assuming a stronger role in their own health care, the shift in emphasis from disease treatment to prevention, and the patient's right to know, the Federal Government should develop an initiative which would support the collection, organization, evaluation, and cheap dissemination of the widely varied lay health literature—a literature that presently is in disarray.

Construction, Renovation, and Retooling of Health Sciences Libraries

Health sciences libraries will shift their focus from being repositories of information to being switching stations for needed information. Planning must begin immediately to convert existing health sciences libraries into health information management centers and to build new ones where necessary.

Technology will help health sciences libraries improve access to and delivery of information. Funding is needed to allow libraries to take advantage of technological developments to meet the information needs of the health sciences community.

Biomedical Information Management and Medical Informatics Training

Information will be managed by individuals from various backgrounds who will need very specialized knowledge, skills, and expertise. Doctoral-level training programs should be developed or strengthened to produce such information professionals. Incentives are needed to draw mid-career professionals to these programs.

Master's-level library and information science programs should be upgraded to provide the knowledge needed to use automated libraries and data bases in biomedicine. Practicing information professionals need continuing education opportunities to upgrade their knowledge base.

Distribution and Utilization of Biomedical Knowledge

Support should be continued for the compilation of all information related to a specific biomedical subject in one publication. Support also should continue for original contributions to biomedical literature as it relates to the scientific, social, and cultural advancement in the health sciences.

Research and Development in Biomedical Information Management

A research agenda in various aspects of biomedical information management is needed to better understand and fulfill the information needs of health professionals.

Improvement and Expansion of the Basic Resources of Health Sciences Libraries

As the biomedical knowledge base expands and information is available from disparate sources, it will be necessary for health sciences libraries to use technology to access remote information to engage in cooperative acquisitions, and to take part in preservation programs to insure the availability of information on a local or regional level.

In an era where some of the information needed cannot be purchased for use in a local library but must instead be accessed on a cost/use basis, it is essential for institutions to develop and implement policies regarding information access, costs, and fees.

RML (Regional Medical Library) Network

The RML Network will continue to use technological advances to improve and speed the delivery of information to health professionals.

The RML Network must continue to link health sciences libraries and also must increase its efforts to directly serve health professionals without access to health sciences libraries. Special efforts to support information services in underserved areas should continue.

Publications to Facilitate Access to the Biomedical Literature

Support should continue for the publication of syntheses and analyses of current developments in biomedical research and practice and health sciences publications that are not commercially profitable.

Support should be given to publications and development of data bases that describe and evaluate health sciences library collections, services, users, and needs.

MEDLARS

Expert systems (to be defined as the use of artificial intelligence through computers to make decisions that have heretofore only been possible for the human mind) to aid in evaluating, indexing, and synthesizing information for inclusion in MEDLARS should be developed. These expert systems, in combination with increased technological sophistication, will promote expanded MEDLARS data bases. Since health professionals will be using the MEDLARS system directly, the search software will need to be "user friendly" to preclude the need for extensive training.

The MEDLARS system should provide gateway access to other information data bases and libraries to facilitate a retrieval of information from all relevant sources for health professionals.

IAIMS

Funding and testing for IAIMS models that reflect differing institutional patterns of organization should continue to promote the critical integration of information in health sciences institutions.

Part 1: Health Information Needs

Historical Analysis

John Shaw Billings foresaw the great need for access to the medical literature with far more prescience than most physicians of the late 19th century, indeed more than many people today. Billings' greatness lay in his ability to solve the problems that he encountered. His solution to the medical literature access problem, when combined with several other sources of indexing and cataloging in the early 20th century (notably those maintained by the American Medical Association), served the health sciences community adequately until World War II.

The modern age of medical science began during the late 1930's and 1940's with the sulfas and penicillin, new knowledge about treating the wounded (shock, renal failure, transfusions, and blood volume expanders), new vaccines and other public health advances, and the dawning of vast new technologies for studying and treating disease. Biomedical research burgeoned. Under the leadership of men such as Lister Hill, the son of an Alabama physician, whose

prescience approached that of Billings, scientists were encouraged to find "the answers" to polio, heart disease, stroke, cancer, and the other diseases affecting Americans. The results, in many instances, have been remarkably successful.

In the early 1960's, it became clear that the vast amount of new information being developed by the biomedical community, most of it federally funded, was not reaching those people for whom it was intended: the academic community to an extent, but especially the practicing physician. Indeed, while many medical centers had developed into impressive generators of basic and clinical research, the health sciences libraries in many of these centers had been woefully neglected. Thus, paradoxically, as a greater need for health sciences information developed, especially to satisfy researchers and educators, there was less and less funding for medical libraries whose specific task it was to meet these needs. A survey made in the early 1960's by the Public Health Association and the Association of American Medical Colleges found that only 15 of 87 medical libraries had sufficient space, that more than one half of these libraries had been built before 1933, and that more than one half of the libraries were either filled to or exceeded their capacity. Clearly, something needed to be done.

Things were being done at the NLM (National Library of Medicine). The new library building was started in 1958 and dedicated in 1961. Congress was relatively generous to the Library, attempting to support its growth commensurate with the growth of the biomedical literature. Yet, because the final act of biomedical research is the publication of results of the study, biomedical literature was growing exponentially. For example, between 1933 and 1963, NLM received some four million titles, while between 1836 and 1933 it received only three million. In addition, during the three years between 1958 and 1961, interlibrary loans at NLM increased 82 percent.

This enormous growth in the medical literature and the inability of the existing system to handle it was studied by a number of committees in the 1950's and early 1960's. The results of these many studies are recorded in thousands of printed words. Perhaps the best one-line summary is found in the Weinberg Report. It said, "Transfer of information is an inseparable part of research and development [and all

those involved] must accept responsibility for the transfer...in the same degree and spirit that they accept responsibility for research and development itself."

The MLA Act was enacted to accept this responsibility.

Health Information Needs in 1985

Unlike John Shaw Billings's very specific medical information needs in the early 1870's, the information needs of today's health scientists, who include researchers, educators, practitioners and paraprofessionals, are far more amorphous. Many of these people do not, until asked, realize that they do indeed have needs. Like the rower who has never used sail, or the sailor who has never used power, one often does not know one's needs until one finds that there are better ways to reach one's goal. So it is with most practitioners and paraprofessionals, and so it is likely to be with educators and researchers.

Many of the problems facing the following four categories of health-care personnel are common to all, yet each has its differences. Though the groupings are arbitrary, each will be treated separately. The needs of each group are discussed in the rank order of importance. It must be noted that these opinions are not based on research data.

Practicing Physicians

Establishing and Using Modern Information Retrieval

Ask perceptive practitioners what is their greatest medical information need and they will tell you it is quick, accurate, cheap answers to very specific questions. Can you give amino-phyllin with cimetidine? What antibiotic is best for a penicillin-allergic elderly man with *S. pneumoniae pneumonia*? The quickest and cheapest method to find the answer, although not always the most accurate, is to ask a colleague. Most practitioners check their often outdated journals or texts, then call a consultant informally, or call their librarian. A good hospital librarian will find the answers to simple questions in five minutes. More complex questions may take hours or days.

While these options are available to many physicians, unfortunately, there are more who do not have access to them or who fail to use those resources that are available. Clearly, a major need in 1986 is for better

facilities for information retrieval, especially in the smaller rural hospitals. An even greater need, and perhaps one more difficult to resolve, is training the current generation of practitioners to use modern information-gathering sources. It is hoped that some of these people, especially the relatively large group who entered practice during the past decade, might respond well to such training.

These litigious times have spawned concern about data bases that give specific, unequivocal answers to questions dealing with the human condition. All people who treat patients know that there is rarely one unequivocally correct answer to any question. Some answers consider only scientific fact, others consider economics, and still others interject regional or national bias. These problems must be addressed as data bases and expert systems for treating patients are developed.

Computer Literacy Among Physicians

In 1986 practicing physicians are becoming familiar with computers through two methods. First, many practitioners either now use or will use computing for their offices, for billing, patient records, and word processing. Second, many physicians are purchasing PCs (personal computers) for family use. There are enough computer users among certain groups of physicians to establish a market for software packages for medical purposes—some good software and some obviously inadequate. Medical societies now are developing electronic mail systems and simple drug data bases and are putting self-assessment programs online. Computer clubs are forming. Physicians are beginning to access data bases directly, thus eliminating the delays inherent in going through an intermediary.

Systems Interface in Hospital Computers

Today's practicing physicians are frustrated by their inability to collect all patient data at one terminal in their hospital or office. Hospitals with early involvement in computing often have one system for data processing, another for pharmacy, and yet another for their clinical laboratory. The hospital library can access NLM's MEDLINE or BRS/Saunders Colleague, but only at the library terminal and not on the wards. Many services, such as radiology, pulmonary function labs, and neurophysiology labs, have no computer access. Physicians must telephone or visit the department or await the typed report the following day.

Frustrations from nonintegration of the hospital computer systems are causing community hospitals to contract with vendors for second- or third-generation computers for first-generation integrated hospital information systems. Hospitals are encountering, among other difficulties, the enormous problem of computers and computing systems being unable to communicate with each other.

Teaching Information Retrieval

The standard setters for the quality of the Nation's practicing physicians are the various boards that examine candidates to see if they are well trained in the science—and the art—of medicine. Today's boards realize that the ability to locate information quickly is an essential skill for all physicians. They currently are struggling with the problems of how to teach this skill in medical school and in postgraduate training programs and how to measure this ability. With the amount of information now available to practicing physicians and with the decreasing half-life of valid information about health care, clearly, all physicians must become well versed in information retrieval from data bases as well as in information gathering from their patients, and in information evaluation—judging that which is valid and that which is spurious.

Changing Emphasis in Medicine

Competitive prepayment health-care programs are rapidly changing the method of health-care delivery in America. Most practicing physicians are no longer allowed the luxury of leisurely investigating each abnormality found in their patients. Rather, the emphasis is now on prevention, health maintenance, and health promotion. How this will change the health sciences information community remains to be seen, but it is clearly a factor to be observed carefully.

Educators

Concerns Shared with Practicing Physicians

Many academic physicians also have some practice responsibilities, if only to make ward rounds with students and house officers. Therefore, many of the problems facing the practicing physician in 1986 face the educator also: the need to obtain quick, cheap, and accurate clinical information; the familiarity with medical computing; the lack of integrated clinical information systems in their hospitals; the lack of standards by the various American medical boards for information retrieval; and the problems of pre-payment plans vis-a-vis health-care information.

Establishing Programs in Medical Information

Academic physicians in 1986 must face not only their own problems with information retrieval, they also must face the even larger problem of what to teach their students about health-care information. As the world enters the Information Age, it is increasingly clear that students cannot store in their brains all the information they will need to practice medicine. They must be taught how to do a few basic things well (histories, physicals, and certain procedures); how to reason clearly; then how to find the information they need. This last function is least well defined at this time.

Among the approximately 130 American medical schools, fewer than 10 have advanced programs in the medical information sciences (to be called medical informatics). These programs are training the relatively few specialists in the field, some as M.D.s and others as Ph.D.s. Some graduates remain at their home institutions; others move quickly into industry; a few go to other academic centers to start their own programs. It is estimated that fewer than 40 medical schools have any formal training in medical informatics for students and house officers. The remaining schools either have ignored the problem, are making plans for the future, or are simply trying to stay alive.

Improving Physical Facilities

Today's library facilities in academic health sciences centers have improved considerably since 1965, yet there are still many centers with woefully inadequate facilities—little space, inaccessible books and journals, and inadequate equipment. Centers that are modernizing their facilities are often calling them information centers, only one component of which is the traditional library containing books and journals. Added to this are learning centers with computer-based instruction, computer-based exams, and a remarkable array of audiovisual equipment.

The Need for Medical Informatics Leaders

As described so well by Matheson and Cooper,¹ today there is the beginning of serious planning for an integrated information system in academic health sciences centers. These systems will include patient data, research data, educational information, and data

bases of all sorts, with easy access at multiple sites. Initially, the system will be expensive, complex, and difficult to manage. There are as yet very few people capable of managing such an integrated information system, either because they lack training in the broad field of medical informatics, do not have academic qualifications, have no research background, or are not equipped by temperament to guide forcefully such a politically unstable project.

Researchers

Health sciences researchers sometimes face all of the problems encountered by practitioners and educators. Therefore, to varying degrees, the preceding comments should be considered valid for researchers also. The following comments discuss those problems that are unique to investigators, either basic or clinical, because it is these people who are concerned with answering the questions that come from practitioners and educators.

Leisurely Search vs. Immediate Retrieval of Information

Somewhat exclusive to researchers is the need for two distinct types of information: one that may be obtained leisurely, the other rapidly. The first is an extensive, thorough, somewhat reflective search of the literature on certain subjects. Unlike practitioners and most educators, researchers have a growing concern with studies worldwide. These searches may take weeks or months and produce voluminous, often irrelevant, material. The second type of information that has become increasingly important to researchers, especially those on the forefront of new diseases (e.g. AIDS) and new fields (e.g. recombinant DNA), is highly specific, notable for changing rapidly, often associated with a for-profit enterprise that is highly competitive. This information may be outdated within weeks; it must, therefore, be accessed very rapidly and updated daily. Much of this information is not available to the scientific community until it is patented, again a unique development of the past decade or two for the scientific community.

Data Bases Beyond Medicine

Biomedical research has extended into fields formerly unrelated to medicine. Whereas during the 1950s and 1960's researchers crossed boundaries within the

medical specialties, now medical research has extended into such areas as engineering, physics, invertebrate zoology, sociology and other disparate fields and disciplines. A major problem in 1986 for health sciences investigators is how to access information in these fields by using the facilities and data bases that are already in place. Clearly, as the system now operates, this is not possible, to the detriment of researchers and their studies.

Nurses and Paraprofessionals

Nursing literature has developed over the years parallel to medical and other health sciences literature. Material unique to nursing is not of a quantity that constitutes a major problem in the immediate future. However, there is a vast array of technologies developing in fields unknown 20 years ago (e.g., respiratory therapy, exercise physiology, and neurophysiology) as well as in nutrition, physical and occupational therapy, and other fields. Each of these has developed its own literature that must be available to others who need it. In addition, there are a number of parascientific fields that have developed literature of their own. These include traditional Chinese medicine and acupuncture, herbal medicine, and chiropractic. While the quantity is relatively small, there is the question of whether or not this literature should be indexed and cataloged.

Lay Health Education Literature

Many health sciences libraries are developing special collections for patients. Some hospitals use this as a marketing tool to attract both patients and physicians. These collections also can be helpful to personnel who produce local television programs for hospital educational channels. These collections usually contain movies and video tapes for in-service education. Unfortunately, it is often difficult to locate the material needed on a specific subject.

There is also a great demand in public libraries for health information. Some public libraries do an excellent job in directing patrons to sound information. Others do not. It is difficult for a librarian to determine what is scientifically sound, and in many instances, patrons alone decide what they wish to read. There is no national system whereby available literature is identified, reviewed for its scientific merit, catalogued, and published.

History of Medicine Literature

Currently, there are excellent resources for the history of medicine literature at NLM and at some of the older, larger health sciences libraries. These must be nurtured at all costs for they are the foundation on which a learned profession is built.

Recommendations for the Future

(1) Health professionals will continue to need quick, inexpensive, accurate answers to specific questions and will increase their direct access to this information. Literature references from online data bases will suffice until access to the information itself is readily available electronically. These electronic information systems should be "user friendly" to facilitate their use.

(2) The problem of underutilization of modern information sources by a large number of physicians, especially practitioners, must be addressed by those who set standards for excellence in health care in America.

(3) In the development of computerized health-care data bases, the concern with litigation prompted by not using or not following the information available must be addressed.

(4) Medical schools, medical societies, medical boards, and others who train physicians, nurses, and paraprofessionals must realize that the world has entered the Information Age, and train health professionals to use and access information.

(5) Major effort must be put into developing integrated hospital information systems that have multiple access points to obtain all clinical information, search data bases, write patient care orders and nursing plans, etc. Plans should be developed at the national level to link the various health-related information systems available in America. These systems must keep up with the rapid development of new medical technologies and the subsequent literature.

(6) Each of our medical schools must look at its current situation in relation to medical informatics and decide its future course. Some will wish to become

leaders in this new field, others simply proficient enough to teach their students well, assist their teachers and researchers, and little more. It is an expensive undertaking, yet it is essential and must not be delayed. Integrated academic medical information systems are the future. While there is no one standard that seems best for all, clearly, all must develop some system to survive.

(7) There are currently few role models in medical informatics with whom students and house officers can identify. There must be more support from the universities for students wishing to specialize in medical informatics. Medical school deans and vice presidents for health affairs must recognize the need for granting academic status to these specialists commensurate with their training and scope of activities.

(8) There is a great need in the research community for information retrieval systems that cross disciplinary lines, so that a physician can search the engineering literature, for example, without having to go to an engineering library.

(9) The health information system must continue to evaluate its position concerning certain nonstandard health-care practices such as traditional Chinese medicine and acupuncture, herbal medicine, and even chiropractic.

(10) Lay health literature is in disarray because no person or group has ever had the responsibility for its organization. As self-help, health promotion, and disease prevention become more prominent each year, the health information system in this country must face this problem and arrive at some answers: Who should be responsible for bringing order to this disarray? How much order is good and how far should it extend? How should this be financed? The Federal Government must play a major role in solving these problems.

(11) The history of medicine collections and programs at NLM and other great health sciences libraries must be nurtured, for they are the foundation on which the learned profession of medicine is built. Medical history is being taught in more medical schools, and there is increasing interest in medical history and in all of the humanities in the medical curriculum.

Part 2: Analysis of MLA Act Programs

Assistance in New Construction and Renovation, Expansion, or Rehabilitation of Existing Medical Library Facilities.

Status in 1965

Academic Health Sciences Libraries

In 1953, the Deitrick-Berson Report, *Medical Schools in the United States at Mid-Century*, indicated a serious problem in the Nation's medical school libraries. In particular, the demands resulting from the expansion of biomedical research activities were outstripping support for current housing. Ten years later, Bloomquist² confirmed the problem:

The crowded and makeshift space in which these libraries are housed presents great inefficiencies for library users and ultimately creates unwarranted expenses for the institution, just as an activity costs more to perform in inefficient quarters than it does in efficient quarters. The problem of damage to library collections should not be ignored either. The crowding, dirt, and improper heating, ventilating, and lighting in ill-housed libraries significantly diminish the life of library materials. Newer features of medical libraries, such as space for storage and use of audio-visual materials, microfilm and photocopy service, and electronic data-processing equipment, must be planned for in building renovation and construction.

Again in 1965, the President's Commission on Heart Disease, Cancer, and Stroke pointed out the continuing strain on inadequate medical school library resources. Huang's study of medical library facilities³ found that only 19 medical school libraries were built or expanded from 1958 to 1964, all of them with space of less than 50,000 net area square feet. It was necessary to develop legislation to authorize the construction and renovation of medical library facilities. Congress responded with the passage of the MLA Act of 1965.

Hospital Libraries

In 1962, there were almost 5,500 short-term hospitals in the United States. Approximately 58 percent (3,192) were estimated to have libraries. It was more likely that a larger hospital would have a library than a smaller hospital.⁴

A 1957 report by the Committee on Hospital Library Architecture of the United Hospital Fund of New York noted the need for adequate library facilities. "Hospital libraries are frequently located in areas which are inaccessible, cramped and generally unsuited to the full development of library service. This is sometimes the case even with recently constructed libraries."⁵

Progress in 1965-1985

Academic Health Sciences Libraries

Between 1967 and 1970, eleven institutions received construction grants under the MLA Act: nine medical schools, one school of optometry, and one school of veterinary medicine. Data suggested that the construction and renovation program needed to expand to meet the needs of other deserving institutions (approximately 25 to 40).⁶

The five-year extension of the MLA Act, which occurred in 1970, provided only modest support for medical library construction. New construction was phased out at the end of the extension, although some renovation funds were available as part of the NLM extramural grants program.⁷

Between 1966 and 1975, 86 medical school libraries were built, expanded, or were under construction. This period represents the greatest expansion in the history of medical school libraries. Some of this building and renovation activity was supported by the MLA Act.³ Much of it sprang from institutional and other support of medical school libraries brought about by the MLA Act and the growing awareness that the handling of technical information is an integral part of science.

Hospital Libraries

Hospital libraries received relatively few Federal construction and renovation dollars during this period, with support coming principally from Resource Project Grants.

A 1969 analysis showed that the average hospital library occupied approximately 1,536 square feet in community hospitals. The same study noted a positive relationship between the total size of the hospital and the space allotted to library activity.⁸ Sparked by new attention to health-care libraries via RML activities and consortial development, many hospital libraries did grow during the 1970's, expanding both space and facilities.

Unmet/Future Needs

(1) During the last decade, the role of the health sciences library began shifting from repository of information to switching station, connecting each health professional to a large array of information systems—from book, to media, to remote data bases. To continue moving in this new technological direction, planning must begin immediately to convert existing health sciences libraries into health information management centers, and to build new ones where necessary. This planning must consider that the traditional structural function of library facilities will be altered dramatically by sophisticated communications technology. Storage space for books and journals in paper and other formats will be reduced. In turn, space will have to be expanded or converted for communications technology (e.g. computers, satellite and television transmission capabilities, etc.), classrooms, and auditoriums.

(2) Procedures must be developed and implemented that allow existing health sciences libraries to be retooled in order to install appropriate systems to meet the information needs of the health sciences community. This will require conversion of material to electronic form, to optical video disks and display devices, and installation of professional workstations and data base management systems.

(3) Despite the growth and recognition of the hospital library, many are still in serious need of physical space renovation, particularly as they move further into an information management environment. Hospi-

tal library facilities require alterations to house new computer hardware and wiring components with linkages to other parts of the hospital's data systems. Space requirements for end user (to be defined as an individual who does his or her own data base searching without the assistance of an information specialist) training and service will increase the demand for square footage in the hospital library as a primary access point for information.

Assistance in the Training of Medical Librarians and Other Information Specialists in the Health Sciences.

Status in 1965

The Lister Hill report to Congress in 1965 identified a "critical shortage of professional personnel trained to meet the special needs of health science libraries and the medical community they serve." This shortage of medical librarians was, in part, underscored by the lack of special programs for medical librarianship. With only two medical librarianship programs available prior to 1966, too few professionals were entering the field, and library services in the medical field were understaffed and losing staff. The MLA Act Training Grants were designed to address this problem.

Progress in 1965-1985

From 1966 to 1971, a total of 115 training grants were awarded to medical librarians. Several studies and an NLM external evaluation of the program indicated that by 1971, the shortage of medical librarians had been largely eliminated. In 1972, eight masters programs in medical librarianship were operational and the eight internship programs developed through grant funding had been reduced to four. Not all graduates in the field were able to find employment and many were hired into nonlibrary settings. Recommendations were made to five new focuses to the training programs.

Since 1972, the thrust in training has been in applying computer technology in the health sciences. The trainees are health scientists, educators, and others with biomedical experience. Through 1984, 109 awards had trained 345 individuals in this area.

Unmet/Future Needs

(1) Availability of qualified library graduates and positions in the field.

The original impetus for the Training Grant program was the "critical shortage of medical librarians."

While that need was filled in terms of numbers by 1971, several changes in the broader environment have made this need apparent again.

Of the 16 programs (8 masters, 8 internships) in medical librarianship designed between 1966 and 1971, a few masters programs still offer one or two medical library courses. Internships were altered in 1972 to focus on computers in medicine with trainers principally health scientists, educators, and others with biomedical experience.

As a result, newly employed library graduates are fully dependent on an intensive internal orientation and often must participate in external training programs in order to be able to function as professionals in the field.

Finally, the number of available positions appears to be increasing as health science libraries expand and reshape their efforts to provide access to information. This increase in options for the graduate librarian makes recruitment of "qualified" librarians more difficult.

(2) Upgraded Knowledge Base Required—Master's Level

The current library school graduate has been educated in a program that does not provide an adequate knowledge base for practice in today's changing health sciences library. These programs again need examination and upgrading to provide baseline knowledge for entry-level graduates who are equipped to practice in automated libraries and search data bases in biomedicine.

(3) New Knowledge Bases—Post Masters, Doctoral, Predoctoral

The future demands health science librarians whose knowledge, skills, and expertise transcend what can be taught in a masters-level program. Attention should focus on major research agendas in the organization,

accessibility, and transfer of knowledge. There is a need to develop bright individuals, credentialing them through doctoral programs, to lead in designing and implementing integrated information programs.

New doctoral programs addressing these needs will draw candidates from a broad spectrum of backgrounds. Initially, however, they should be structured to attract current library administrative personnel and middle management so that the development agenda will be quick and effective. Incentives should draw midcareer individuals to the problems.

(4) Continuing Education Opportunities

A large number of today's medical librarians have been forced to learn about new technology on the job. Such learning often has neglected an understanding of the basic theoretical underpinnings of the technology.

Additionally, while many middle managers and library administrators may have had a course in library administration and management, theory and techniques have seen major changes in the last 20 years. Most are hard pressed to design new and improved systems since they lack background in technological advancements, systems theory, and management techniques. Individual efforts to stay current through reading, collegial exchange, and periodic training programs have been inadequate.

Formal continuing education for practicing librarians should advance the dissemination of information to health-care researchers, practitioners, and students as the newly trained individuals become more effective at solving information management problems.

(5) Health Professional Training

Since 1972, NLM has offered training grants in the application of computer technology to the health sciences. Trainees have been health scientists, educators, and others with biomedical experience. The need for such training continues. The publication of the GPEP report⁹ underscored the importance of increasing the understanding of information management among practitioners, researchers, and students. As access to computer technology grows and information mushrooms, management of information becomes more and more critical to daily functioning for the health practitioner.

Training must be targeted to the health science student so that skills are learned early and become part of everyday life. Attention also must be paid to training trainers—educators who can teach theory, principles, and practice of information organization and access. Beyond that, some continuing training assistance is necessary for potential leaders in health care who can transform knowledge into useful products or who can seek new knowledge in biomedical information management.

Assistance in Compiling Existing and Creating Additional Material That Disseminates Information on Scientific, Social, and Cultural Advancements in the Health Sciences, Through Fellowships to Physicians, Health-Care Professionals, and Scientists.

Status in 1965

One of the mandates of NLM is the organization of biomedical information. This mandate is fulfilled by cataloging, indexing, and abstracting portions of the literature. Organization of the literature also is achieved by producing reviews, synopses, handbooks, and other forms of secondary publications. Their chief purpose is to provide additional means of access to the literature. With the rapid expansion of scientific knowledge following World War II, NLM recognized the need for the scholarly compilation of all information related to a specific biomedical subject that had not been brought together in one publication, and for original contributions related to the scientific, social, and cultural advancement in the health sciences.

Progress in 1965-1985

The purpose of this program has been to assist in the preparation of major scholarly treatises and book-length analyses of the literature on important health topics by highly qualified scientists, practitioners, and scholars. The program began in 1966 as fellowship awards under the training grant authority and changed to project grants under research authority with the first extension of the MLA Act in 1970. In 1973, the emphasis again changed to that of individual authorship, one-year projects, and the requirement for detailed plans and publication arrangements.

Since 1976, 10 books have been published, all of them favorably reviewed. Distinguished scholar-scientists have completed major works on toxicity of the liver, epidemiology of diabetes, and most recently, the evolution of the American municipal hospital system, as well as a major introduction to legal principles, issues, and controversies affecting health professionals in the performance of their work.

Unmet/Future Needs

- (1) Continue to provide treatises that integrate all of the literature on a single subject where none has been written.
- (2) Continue to emphasize single-author works of authoritative scholars to insure readability and the perspective of a special point of view.
- (3) Continue to support the development of works that emphasize health and social issues (e.g. informed consent).

Assistance in Conducting Research and Investigations in the Field of Medical Library Science and Related Activities and in Developing New Techniques, Systems, and Equipment for Processing, Storing, Retrieving, and Distributing Information in the Sciences Related to Health.

Status in 1965

In 1965, nearly all tasks in medical libraries were performed manually—checking out books, recording the receipt of journal issues, preparing bibliographic searches by checking indexes and abstracts. The latest in technology was the photocopy machine. This lack of technology contrasted with the volume and character of a biomedical literature that posed peculiar problems of storage, retrieval, and transmission. Nearly all aspects of current medical library science needed to be reassessed to develop more efficient skills and technology. In addition, research was needed in related areas such as the uses of information by scientists, teachers, and practitioners and their searching techniques and attitudes; medical terminology and classification; machine indexing; and graphic image storage and retrieval.

Progress in 1965-1985

The MLA Act research grant program supports basic research into fundamental issues of health information generation, reorganization, and utilization. It also helps develop new methods of information processing and testing those methods in operating conditions. Research grants have been of two kinds: health sciences librarianship and computers in medicine.

The first five-year assessment of this MLA Act program suggested that the funds invested were unrewarding for libraries, since results were, at best, only peripherally relevant. It was also determined that there were numerous straightforward studies that could improve the quality and quantity of service offered by health sciences libraries, but that individuals best able to identify instances of need and opportunity are frequently ill-equipped because of their service training, orientation, and responsibility to design, carry out, and evaluate first-rate research projects.

The program took on new vigor in 1979 with the adoption of the computers-in-medicine program, which involved research in the application of computer technology in clinical problem solving and decision making, in assisting health personnel in better utilizing research results and health knowledge, and in innovative health data management.

During the last decade, research in the field of medical information science has become synonymous with medical informatics. This emerging field of inquiry is concerned with improving the organization, accessibility, and transfer of biomedical knowledge.

Unmet/Future Needs

Develop a research agenda including but not limited to the following: development of new techniques, systems, and equipment for processing, storing, and retrieving biomedical information; study of the uses of information by scientists, teachers, and practitioners; comparing information systems developed for the same purpose but where little or no objective comparison of their strengths or weaknesses is attempted; studying information-handling skills of students, practitioners, and researchers in order to develop scientific methods to promote lifelong learning; designing techniques and systems to effectively

assimilate new information and provide access to knowledge in order to improve receptivity and utilization; developing ways to deliver the knowledge desired rather than a document; developing techniques for the interpretation of data and the evaluation of the biomedical literature; developing the methodology to promote relevant research; and establishing the means to expand the knowledge base on which further advances must be made.

Assistance in Improving and Expanding the Basic Resources of Medical Libraries and Related Facilities.

Status in 1965

Academic Health Sciences Libraries

In 1965, the plight of the Nation's health science libraries was critical. Only 14 of the 87 existing medical school libraries had the recommended level of 100,000 volumes, and few had the recommended 1,500 journal subscriptions. Organization of the material in these libraries suffered from a lack of resources and trained staff, resulting in large backlogs of tasks such as cataloging and indexing. The libraries were able to support only rudimentary reference services that were insufficient to meet the research and educational needs of the institutions they served. They also lacked the equipment (photoduplication) necessary to speed the processing of materials.¹

Hospital Libraries

A review by the American Hospital Association in 1962 revealed that, of the 5,500 short-term hospitals surveyed, only 58.6 percent had professional libraries. The collections in these libraries were inadequate; the average number of books held was 561, and current journal subscriptions numbered an average of 33. Library staff was primarily part-time and provided a minimal level of service and organization of library materials. In 1962, only 70 percent of the libraries provided reference services, 26 percent borrowed material on interlibrary loan, 21 percent provided bibliographies, and 12 percent provided photocopies of materials.⁴

Progress in 1965-1985

MLA Act Programs Instituted

To help public or private nonprofit health sciences libraries establish, expand, or improve their resource and information services, NLM began a program of Resource Grants. In 1966, formula grants provided assistance for acquiring library resources. In 1970, emphasis was changed to improving and extending information services with support from Project Grants and to establishing or improving libraries in community health facilities, primarily hospitals, through Improvement Grants. Approximately 16 percent of the Nation's hospitals have received support and developed basic information services.

Academic Health Sciences Libraries

The 1983/84 *Annual Statistics for Medical School Libraries in the United States and Canada*¹¹ reveals that the collections, organization, and services of academic health sciences libraries have improved substantially since 1965. Of the 132 libraries reporting statistics, the mean number of volumes in the collections is 152,006 and the average number of journal subscriptions is 2,159. A full range of services is provided by all libraries, including interlibrary lending and borrowing (over 293,000 items borrowed and 969,716 items lent); over 2 million information contacts, and over 130 million photocopies made. Most impressive is the fact that all academic health sciences libraries provide MEDLINE searches (over 242,000 accesses), and all but a few search other online data bases (over 40,000 accesses). Management of academic health sciences libraries collections has improved considerably; most notable is the fact that 89 percent of the reporting libraries use an automated cataloging system. Equipment such as photocopiers, so badly needed in 1965, have become commonplace in academic health sciences libraries, as have online search equipment and equipment to access bibliographic utilities. A number of academic health sciences libraries have begun to use computers for internal functions such as circulation and journal receipt.

Hospital Libraries

Hospital libraries have increased in both number and sophistication since 1965. The number of libraries grew by 13 percent between 1969 and 1979,¹² and most impressive is the number and educational background of staff managing these libraries. A study of libraries in Region Seven of the RML Network reveals that in 1969, only 40 percent of the hospital libraries were staffed by librarians, as compared to 69 percent in 1984. The number of hospital librarians with MLS degrees increased from 35 in 1969 to 249 in 1984. Collection size also improved significantly in Region Seven. In 1969, 70 percent of the hospital libraries subscribed to 50 or fewer journal titles; in 1984 only 40 percent of the libraries subscribed to this small number of titles. As in the academic health sciences libraries, the range and amount of services provided also have increased. In 1969, 30 percent of Region Seven libraries provided manual or computerized bibliographies, as compared to 100 percent in 1984; 41 percent provided photocopy services in 1969, and 84 percent provided this service in 1984. Interlibrary lending and borrowing activities increased substantially in this same period, with 56 percent of the libraries borrowing over 200 items in 1984 as opposed to 14 percent in 1969, and 47 percent of the libraries lending over 200 items in 1984 as compared to 4 percent in 1969. Organization and currency of the collections also improved with more libraries regularly weeding and cataloging their collections.¹³ Access to needed equipment also has improved considerably, with photocopy machines, computer search equipment, and microcomputers becoming more prevalent in hospital libraries.

An evaluation of the Improvement Grant Program by Matheson and West¹⁴ shows that grant recipients outperformed libraries that applied for but did not receive awards and libraries that did not participate in the grant program. For example, libraries receiving grants showed a 109-percent gain in the number of current journal subscriptions, as compared to a 20-percent gain in the unsuccessful applicant group, and an 86-percent gain in the nonparticipant group.

Unmet/Future Needs

(1) Through the use of technology, health sciences libraries will be able to improve access to and delivery of information. Funding is needed to allow libraries to take advantage of the latest technological developments.

(2) The diversity and sources of information needed by today's health professional are expanding. Health sciences libraries must be prepared to serve as switching stations to access remote information, in addition to continuing in their roles of organizing and storing information.

(3) Expert systems should be developed to aid in the organization and control of information collected by libraries.

(4) As biomedical knowledge and sources of knowledge expand, it will become increasingly difficult for libraries to collect all pertinent information needed by their users. Cooperative acquisitions and preservation programs that provide access to needed information on a regional level should be encouraged.

(5) Continued service to health professionals requires continued analysis of their needs and the ability of health sciences libraries to meet them. It is recommended that national mechanisms for the effective collection and analysis of data concerning information services and their related research and educational activities be developed.

(6) In an era where much of the information that health professionals need cannot be purchased for use in a local library but must be accessed on a cost/use basis, it is essential for institutions to develop and implement policies regarding information access, costs, and fees.

Assistance in Developing a National System of RMLs Each With Facilities of Sufficient Depth and Scope To Supplement the Services of Other Medical Libraries Within the Region It Serves.

Status in 1965

Expanding medical literature and the need for increased speed in accessing it calls for measures to improve availability of books, journals, and other

informational material. A network of regional medical libraries would help fill this need and also would relieve NLM of its responsibility as the "libraries' library."

Progress in 1965-1985

The RML Program was developed to provide health professionals with timely, convenient access to health-care and biomedical resources. Initially, the Nation was divided into 11 regions. In 1983, the 11 regions were reconfigured into 7 to increase the proportion of funds going into direct information services. Over the years, the program developed a network of health sciences libraries that shares collection and staff resources, and uses modern technology to improve access to information. Major accomplishments of the RML Program include:

- (1) Developing an effective network of over 3,300 libraries to provide information in books, journal articles, and audiovisuals to health professionals.
- (2) Using modern technology to locate serial titles not held locally so requests can be filled quickly and cost-effectively.
- (3) Expanding access to online systems to more than six million health professionals and assisting in providing online training to librarians and health professionals.
- (4) Training hospital library personnel in basic library management and delivery of information services. Each year this training improves information services to more than 1,000 health professionals.
- (5) Fostering the development of more than 270 hospital library consortia for resource sharing.
- (6) Developing and implementing a regional automated document request and routing system that handles an estimated 50,000 requests a year.
- (7) Identifying geographic areas in which health professionals are underserved and implementing programs to provide services in 10 to 20 of these each year.

Unmet/Future Needs

Although the RML Network has improved dramatically the access to information by health professionals, technological advances will continue this improvement. Specific programs that should be undertaken by NLM and the RML Network include:

- (1) Development and implementation of a nationwide automated document request and routing system to save money and provide more rapid delivery of requests.
- (2) Development of improved mechanisms for the delivery of documents, including telefacsimile and optical disk technology.
- (3) Development of improved mechanisms to locate books and audiovisuals, including access to this information directly by end users.
- (4) Development of improved information on the contents of books so that requestors can select the transmission of needed portions only, rather than the loan of the physical volume.
- (5) Development of improved mechanisms for access to non-health-related materials needed by health professionals by facilitating linkages with other information networks and data bases.
- (6) Facilitation of improved regional collection development to insure that needed materials are acquired and retained in the regions.
- (7) Development of a National Biomedical Reference Referral Network.
- (8) Development of a National Biomedical Preservation Plan integrated into the national preservation plan for the entire scholarly record.

Access to the RML Network is readily available to health sciences libraries with trained personnel. Use of the network by individuals without access to health sciences libraries and by institutions without developed information services and sources needs improvement. In addition, developed libraries need to employ technology to improve their provision of information services. This can be accomplished by:

- (1) Developing ways to provide basic levels of information services to isolated geographic areas in which health professionals are still underserved.

- (2) Encouraging enhanced participation in the RML Network by network libraries and health professionals.
- (3) Examining appropriate levels of access to the network in light of technological developments.
- (4) Encouraging the use of current technological advances in order to disseminate information.
- (5) Implementing at test sites and evaluating the use of modern technologies that can enhance the delivery and use of health-related information.

Provide Financial Support to Biomedical Scientific Publications.

Status in 1965

The fundamental rationale for NLM's mission recognizes that health is a national priority and that health research is a major national investment. Not only is NLM responsible for collecting and organizing, but it also must disseminate health research information. To realize the full benefit from the investment in research, every possible means must be taken to stimulate the effective dissemination of that information.¹⁵ For NLM to accomplish that objective, it had always been necessary to catalog its books and index its journals. With the increasing volume and complexity of biomedical literature, it became necessary to develop other secondary publications that provide efficient and targeted access to selective parts of the literature: reviews, indexes, abstracts, and handbooks. Translation of foreign biomedical literature was also important so that U.S. health-care professionals could keep abreast of medical research and progress made elsewhere. Supporting works that would improve the coverage of the biomedical literature, but were not commercially viable, was also an objective.

Progress in 1965-1985

The grants and contracts under this MLA Act program have assisted in preparing, producing, and disseminating biomedical scientific publications that were not commercially viable and that would provide new points of entry to the medical literature. This effort, begun in 1966, supported a wide range of publication activities, including critical, analytic review of the status of medical research and practice; secondary literature tools such as handbooks and biomedical bibliographies; studies in the history of medicine; and translations.

In 1974, the program emphasis was changed to providing selective, short-term support for critical reviews and monographs in special areas of health research and practice.

Studies supported include critical reviews and monographs on current and past developments in medical research and services, publications in biomedical communications and health information science, translation of significant foreign-language monographs, and proceedings of symposia important to U.S. health interests.

Over 439 publications have been supported by this program. Reviews indicate these publications have been of consistently high quality and that a significant number of the publications have direct relevance to improvement of health-care delivery.

Unmet/Future Needs

- (1) Continue to make important contributions to biomedical knowledge by providing syntheses and analyses of current development in biomedical research and practice for the use of U.S. health practitioners, health researchers, and medical educators.
- (2) Continue to provide low cost, time-limited support for important publications in the health sciences that are not commercially profitable.
- (3) Continue to identify areas of the literature where such publications are needed.
- (4) Support publications and the development of data bases that would describe health sciences library collections, services, users, and needs.

MEDLARS

Status in 1965

Since its founding in 1836, NLM (formerly the Library of the Surgeon General's Office) has had the major responsibility for publishing the national bibliographies in medicine, the *Index Catalog of the Library of the Surgeon General's Office* (the first volume of which was produced in 1880), and the *Index Medicus* (which began publication in 1879). The purpose of the *Index Catalog* and the *Index Medicus* was to provide bibliographic access to the book and journal literature owned by the Library. Similarly, the need for bibliographic control of a burgeoning medical literature resulted in the development of NLM's MEDLARS. By the late 1950's, the number of journals and articles to be indexed by NLM for inclusion in the *Current List of Medical Literature* (at that time the monthly index serving as the key to medicine's journal literature) strained NLM's ability to keep the publication current. The Library developed a plan to produce the *Current List* using punch cards containing bibliographic information describing each journal article. The plan called for the cards to be sorted by machine and the output photographed by a high-speed camera to produce a photo-offset negative for printing. While the system produced the *Current List*, the machines' card-sorting capabilities were too slow to make the selective retrieval of bibliographic information practical.^{6 16}

Not long after that, advances in data processing techniques enabled NLM to produce *Index Medicus* (the union of NLM's *Current List of Medical Literature* and the American Medical Association's *Quarterly Cumulative Index Medicus*) and paved the way for the development of a computerized bibliographic service for the health professional. The indexing information for each journal article was fed into the system and stored on magnetic tape, which was then manipulated by a digital computer. The processed tape activated a high-speed composing device that produced photographic masters for printing *Index Medicus*. The same bibliographic data base used for publishing *Index Medicus* was now accessible for selective information retrieval, and the first MEDLARS searches were formulated in 1964.

Progress in 1965-1985

Trained search analysts in selected academic health center libraries sites around the country formulated MEDLARS searches and sent them to NLM for computer processing. Results were returned to the initiating institution for distribution to the library's clientele. While it was possible to process only 20,000 MEDLARS searches per year, the ability to selectively search the *Index Medicus* data base was a milestone in the application of technology. It improved immeasurably the speed and quality of literature searches that health sciences libraries could provide their users. MEDLARS foreshadowed the development of myriad data bases whose selective access for the purpose of developing tailor-made bibliographies transformed not only health sciences library service, but also service in public, special, and academic libraries in the United States and abroad.

NLM's current system, MEDLINE (MEDLARS online), permits the user to hold a dialog—online—with the computer by typing in responses to prompts and queries at the computer terminal keyboard. MEDLARS data bases are accessed mainly through MeSH (Medical Subject Headings), the controlled vocabulary used to index journals for *Index Medicus*. When the searcher finds the necessary references, citations may be printed at the terminal. NLM's data bases are used by private vendors who lease MEDLARS tapes and individual health professionals, as well as over 2,000 health sciences institutions (mainly libraries). MEDLINE, which contains about 800,000 citations from 3,000 biomedical journals, is the largest and most frequently used of NLM's data bases.

Unmet/Future Needs

(I) Expert systems to help evaluate, index, and synthesize information for inclusion in MEDLARS should be developed. Examples of such expert systems include:

- (a) Quality filters (i.e., means to evaluate articles, protocols, and other information in the literature of biomedicine. Such an evaluation might be based on citation analysis and randomized control trials.)
- (b) Automated indexing

(2) Increased technological sophistication and expert systems make it possible to store larger quantities of information economically and facilitate the addition of this information to the MEDLARS data base. Examples of types of information that could be included are:

- (a) Contents of books
- (b) Synthesized biomedical information

(3) As health professionals become directly involved in information management and access, it will be essential to design increasingly "user friendly" software that does not require extensive training.

(4) The increasingly interdisciplinary nature of scientific investigation will require access to information in other data bases and libraries. The MEDLARS system should be designed to provide access to these information sources through gateways.

Integrated Academic Information Management

1983-1985

In 1983, NLM began a special new initiative: IAIMS. This program was developed in response to recommendations in an NLM-supported study by the Association of American Medical Colleges, *Academic Information in the Academic Health Sciences Center: Roles for the Library in Information Management*. The study addressed the need for networks that would facilitate the flow of recorded biomedical knowledge throughout academic health science centers and hospitals. It specifically recommended support for prototypes that would encourage such networking.

The IAIMS initiative originally awarded contracts to four academic health science centers to plan prototype design and implementation. Since the original four awards, other institutions have received funding for IAIMS planning activities.

Unmet/Future Needs

There is widespread recognition that health sciences libraries across the country will need to develop networks for biomedical institutional environments. All such networks, however, may not be identical or even parallel since institutional and individual needs differ from location to location. Funding for IAIMS models and for alternatives to IAIMS should be continued if biomedical information is to be accessible and usable within the academic health center and within the hospital.

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Appendix B: NLM Planning Process

In January, 1985 the Board of Regents of the National Library of Medicine resolved to develop a long-range plan to guide the Library in wisely using its human, physical, and financial resources to fulfill its mission. The Board recognized the need for a well-formulated plan because of rapidly evolving information technology, continued growth in the literature of biomedicine, and the need to make informed choices of intermediate objectives that would lead NLM toward its strategic, long-range goals. Not only would a good plan generate goals and checkpoints for management, actually a map of program directions, but it would also inform the various constituencies among the Library's users about the future it sought and could help to enlist their support in achieving that future.

At the Board's direction, a broadly based process was begun involving the participation of librarians, physicians, nurses, and other health professionals; biomedical scientists; computer scientists; and others whose interests are intertwined with the Library's. A total of 77 experts in various fields accepted invitations to serve on one of the five planning panels. Each panel addressed the future in one of the five domains that encompass NLM's current programs and activities. The domains, which provided the panels a framework for thinking about the future are:

1. Building and organizing the Library's collection
2. Locating and gaining access to medical and scientific literature
3. Obtaining factual information from data bases
4. Medical informatics
5. Assisting health professions education through information technology

The Library chose a planning model with three components. First, it incorporates a general, somewhat indistinct vision of the future 20 years from now in medicine, library and information science, and computer-communications technology. That environment cannot be forecast precisely, but we can speak of a "distant" goal. That goal is seen as a societal objective whose attainment involves many organizations and

agencies. NLM has a major role to play in achieving the goal and must plan its part. Second, while the 20-year goals are indistinct, there are opportunities for and impediments against achieving them. The opportunities and impediments can be more clearly envisioned because they appear to lie roughly 10 years away. Third, the specific steps that should be taken to remove the impediments and take advantage of the opportunities should be programmed for 3 to 5 years.

The planning process also involved participation within the Library. The Director provided his version of the future in the form of a "Scenario: 2005," which was distributed to panel members and Library staff. NLM staff prepared background documents that reported NLM achievements in the five domains, identified issues, and reviewed current planning. Senior NLM staff members also acted as resource persons to the planning panels.

At the end of the planning process, each panel formulated recommendations and priorities for future NLM programs and activities in the domain under its purview. The five panel reports were reviewed by the Board of Regents in June 1986. The Board then asked the NLM staff to analyze and reconcile their findings, eliminating any duplications and consolidating the recommendations. This synthesized plan is presented in this volume. Together with the planning panel reports, it represents the official Long-Range Plan of the Board of Regents of the National Library of Medicine.

Photographs were obtained from the several Bureaus, Institutes, and Divisions of the National Institutes of Health (including the Office of the Director, NIH, the Warren G. Magnuson Clinical Center, and the National Institute on Aging), the Uniformed Services University of the Health Sciences, the World Health Organization, and William A. Yasnoff, M.D., Ph. D.

